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PROCEEDINGS OF
THE LINNEAN SOCIETY OF LONDON

151st Session (1938–9) Part 3

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PROCEEDINGS OF
THE LINNEAN SOCIETY OF LONDON

151st Session (1938–9) Part 3

PROCEEDINGS OF THE GENERAL MEETING
16 MARCH 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President,
in the Chair

The Proceedings of the General Meeting held on Thursday, 2 March 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Leonard Richmond Wheeler, Charles Russel Metcalfe, and Walter Samuel Millard.

A certificate of recommendation of the following candidate for Fellowship was read :—For the first time, in favour of Ivan Robert Dale.

Certificates of recommendation of the following candidates for Foreign Membership were read for the first time :—Alfred Ernst, William Albert Setchell, Alfred Rehder, Willem Marius Docters van Leeuwen, and William King Gregory.

In accordance with Chap. X, Sect. vii of the Bye-Laws, the following Fellows were elected, by show of hands, as Auditors of the Treasurer's accounts for 1938–39 :—

Representing the Council :	Dr. B. Barnes. Mr. D. J. Scourfield, I.S.O.
Representing the Fellows :	Dr. T. A. Sprague. Mr. H. R. Hewer.

The President reported the deaths of Miss Dorothea Frances Matilda Pertz, F.L.S., and Professor Edmund Beecher Wilson, F.M.L.S.

Mr. J. R. Norman, F.L.S., gave an account, illustrated with lantern-slides, of 'A living Coelacanth from South Africa; a fish believed to have been long extinct'.

Abstract.—

The circumstances of the capture of this remarkable fish, as reported in the press, are roughly as follows. It was obtained by a commercial trawler fishing in about 40 fathoms off East London, Cape Province, near the end of last December. It lived for some time after capture, and was described as being of a brilliant steel-blue colour, with 'big, dark-blue eyes'. The specimen was five feet in length, weighed 127 lb., and was noticed to be unusually oily. On reaching port the fish was seen by Miss Courtenay-Latimer, the Curator of the East London Museum, who communicated with Dr. J. L. B. Smith, of Rhodes University College, Grahamstown, who was then on holiday at Knysna, some four hundred miles away. Unfortunately the letter was delayed, and Dr. Smith did not receive it until ten days later. By this time the fish had been skinned and mounted by the local taxidermist, and the putrified body had been thrown away. Fortunately, it appears that a part of the vertebral column and pectoral girdle, as well as the skull still remain. Dr. Smith has given a preliminary account of the fish, together with an excellent photograph, in 'Nature' (vol. CXLIII, no. 3620, March 18th, 1939, p. 455), and has named it *Latimeria chalumnae*. A full report will be published in due course in the 'Transactions of the Royal Society of South Africa', and will be eagerly awaited by zoologists and palaeontologists alike.

A glance at the photograph, a copy of which first reached the British Museum (Natural History) on Thursday, March 2, shows at once that there is no place for this fish in any classification of existing fishes. It is clearly a member of the subclass of Bony Fishes, the Crossopterygii, a group believed to be represented to-day only by the comparatively degenerate Lung-fishes (Dipneusti) of the fresh-waters of Northern Queensland, tropical Africa, and South America. It is referable to the order Actinistia, and Dr. Smith is undoubtedly correct in placing it in the family Coelacanthidae, of which it would appear to be a typical member.

The earliest Coelacanths occur in the rocks of the Upper Devonian period, believed to be at least 300,000,000 years old: the family is abundant and widespread throughout the Carboniferous, Permian, and Triassic, being found in Western Europe, North America, South Africa, Madagascar, and Spitzbergen. Later, they are less abundant, with fewer types, until the Upper Cretaceous, when they were believed to have become extinct. A remarkable feature of the Coelacanths is the very slight change that they have undergone in external appearance during the long period from Devonian to Cretaceous, a period of not less than 250,000,000 years. Even more remarkable is the fact that the present fish from South Africa seems to be just as typical a member of the family as the fossil forms. In some respects, at least, it would appear to resemble more closely such forms as *Undina*, of the early Mesozoic, than the later forms such as *Macropoma* found in the Chalk. The fact that no traces of fossil Coelacanths are to be found in strata later than those of the Upper Cretaceous makes the discovery of a living fish in South African seas a very remarkable one.

Features which are clearly shown in the photograph include the curious lobate second dorsal, anal, pectoral, and pelvic fins, which are of the typical Crossopterygian form ; the gephyrocercal tail, with the protruding axial supplementary fin ; the single, heavily ossified opercular plate ; and the large gular plates below the jaws, which take the place of the branchiostegal rays of modern fishes. A small spiracle is said to be present above and behind the eye, but no mention is made of the form and position of the nostrils, a point of considerable importance. It is stated that the skeleton of the living fish was found to be cartilaginous and the vertebral column apparently tubular. In the fossil forms the central part of the vertebral column is wanting, and this was probably cartilaginous, but the neural and haemal spines are well ossified. A unique feature of the extinct Coelacanths, and one which may be verified in many fossil specimens, is the ossified air-bladder, and it will be of considerable interest to learn whether this was noted when the present fish was skinned.

It is a matter of interest to enquire as to the probable habitat of the African fish and the chances of securing further specimens. It is difficult to believe that it is ordinarily to be found on the grounds trawled by commercial vessels, although it is possible that it has been brought up previously with a catch of food-fishes and returned to the sea by the fishermen. My own opinion is that the fish is either to be found at much greater depths, or that it is an inhabitant of comparatively shallow water in regions where the bottom is rocky and where trawling is impossible. Its general build is that of a slow swimmer, and it is more likely to be a demersal form than one from the mid-water. If found in the middle layers, the chances of obtaining further specimens are slender, since a large and active fish can readily elude any of nets at present in use, which must of necessity be towed at comparatively slow speeds : if an inhabitant of the bottom, long baited lines would appear to hold out the best hope of success. In any case, it is to be hoped that every effort will be made to secure further specimens, so that the complete anatomy of this unique genus may be studied.

Discussion.—

Sir A. Smith Woodward, F.L.S., remarked that the discovery of a living Coelacanth fish seemed surprising, because no member of the group had been found in any rocks later than the Cretaceous. There were, however, some modern types of fishes, such as certain Berycidae and Halosauridae, which were known only from the Cretaceous and existing seas. The immediate descendants of many Cretaceous fishes retreated to ocean depths and so escaped preservation in the Tertiary deposits which were formed chiefly in the shallower seas. The persistence of even small characters in these long-lived groups of fishes is remarkable. In the new Coelacanth there are the same number of rays in the anterior dorsal fin as in the Cretaceous *Macropoma*. In the living Berycoid *Hoplopteryx* the complicated arrangement of the crests and ridges on the skull is exactly the same as in the fossil species in the Chalk.

Prof. D. M. S. Watson (Visitor) emphasized the very great importance of the discovery, because it provided for the first time an opportunity of estimating the accuracy of published reconstructions, based on fossil material of extinct animals, by direct comparison with an actual living representative. It is of the very greatest importance that further specimens should be obtained as soon as possible and their anatomy and physiology described in detail.

Dr. E. I. White (Visitor) remarked that the discovery of this living Coelacanth was the most important event in Systematic Zoology since the recognition 70 years ago by Günther of the Barramunda as a living representative of the supposedly extinct group of Ceratodont Lung-fishes. But the event was more important than just the survival of an archaic type, for on the Coelacanths were partly based principles concerning the development of vertebrate animals in general; for instance, that concerning the development of the head-bones and their relationship to the organs of the sensory canal system. He congratulated Mr. Norman on his interesting exposition of this most important discovery.

Professor W. Garstang, F.L.S., asked if the contents of the stomach had been noted.

The President said that botanists would be thrilled by the sight of living material of Pteridosperms or other plants known now only in a fossil state, but could appreciate a good deal of the scientific interest of the present discovery. Although it was regrettable that the specimens had been skinned and certain opportunities thus lost, it was a matter of congratulation that sufficient interest had been shown in what appeared merely unusual to enable a valuable contribution to be made to biological science.

In reply to Professor Garstang, Mr. NORMAN stated that no data were as yet available as to the stomach-contents of the specimen.

Dr. WINIFRED E. BRENCHLEY, F.L.S., gave an account, illustrated with lantern-slides, of 'The Vitality of Weed Seeds'. [Printed in full below.]

Dr. R. MELVILLE, F.L.S., gave an account, illustrated with lantern-slides, of 'The application of Biometrical Methods to the study of Elms'. [Printed in full below, p. 152.]

The following paper was read in title :—

'Studies in the Arabian Orthoptera.—II. New and little-known Mantidae and Phasmidae.' By Dr. B. P. UVAROV, F.L.S. [This paper has been published in the Journal, Zoology, XL, pp. 547–59.]

THE VITALITY OF WEED SEEDS.

BY DR. WINIFRED E. BRENCHLEY, F.L.S.

THE length of time that seeds retain their power of germination is a matter that has attracted much academic interest for many years, a good deal of the work dealing with the physiological problems concerned.

Some claims of longevity are almost fantastic, the classic instance being that of 'mummy' wheat from Egyptian ombs ; but such claims are probably fraudulent. Prof. Ohga, in Manchuria, obtained many germinable fruits of *Nelumbo nucifera*, the Indian Lotus, from an old peat bed, and estimated he probable age of the seeds as from 150–400 years. Both Becquerel (1907) and Ewart (1908) agreed that on the whole eeds retain their viability longer when buried in the soil han when stored in dry air.

When deep excavations are made, as when digging a well, he flora that appears on the material thrown out is often very urprising. Such dumps may rapidly be covered with charock, comprising various species of *Brassica*, or sometimes oppies or other plants. There is often no known history f cultivation of the excavated area, and the seeds are too eavy and too numerous to be transported by wind or animals. t has been reported, on good authority, that when one of the ones of Stonehenge fell, the torn up earth at the base was rapidly covered with charlock, though the site is now isolated from all arable land. The historic fields of Flanders poppies after the Great War are not so inexplicable, as much of the land concerned was under cultivation and the shelling of the soil helped to scatter the abundant seed supply far and wide.

It is not too easy to get reliable information as to the longevity of seeds, owing to the long period of time that must elapse and the difficulty of being certain of the condition throughout that period.

Experiments in which seeds are buried in soil artificially and examined after the lapse of various periods, are open to certain objections, especially as it is not possible exactly to reproduce the conditions of natural burial. Such experimental seeds must be segregated if they are ever to be found again, and they do not therefore come into the intimate contact with the soil that occurs when seeds are shed on the surface and carried or washed down by various agencies. Some evidence of the length of time seeds can lie dormant in the soil was obtained from a field at Rothamsted which used to carry arable crops, but which has been left derelict since 1882, owing to its waterlogged condition. Thirty-two years after the field had fallen down to grass, 74 viable weed seeds were proved to be present in four samples totalling one square foot in area. Similar sampling from other fields showed numbers of arable weed seeds increasing in number as the period of grassing-down decreased. After ten years under grass the number of viable seeds was very heavy, 457 per square foot, representing about 20 million seeds per acre which had retained their power of germination for at least 10 years.

This question of the vitality of seeds is of great practica importance from the point of view of soil-cultivation. One of the great difficulties facing the cultivator is the competition for food and water caused by the presence of weeds among the crops, and the problem of weed eradication is often acute Perennial and annual weeds offer distinct problems, but here only the annuals are considered.

The great majority of these are derived from seeds which are already present in the soil, though a certain number may be introduced with the crop seeds. The cultivation for the crops favours the germination of the weed seeds but by careful treatment these seedlings may be very largely eliminated. If all the buried seeds germinated, the problem would be easy, but unfortunately large stores of viable seed remain to cause future trouble. The weed seed population may be enormous, and during recent years there has been a unique opportunity at Rothamsted to study this point.

Broadbalk wheat field has carried wheat every year since

1843. This has always been autumn-sown, so that very little time is available between harvest and sowing for cleaning the land. By 1925 poppies and black bent (*Alopecurus agrestis*) were dominating the situation to the detriment of the wheat crop, and something drastic had to be done. As the crop could not be entirely foregone for a single year because of the necessity to maintain the continuity of the records, three-fifths of the field was intensively fallowed for two successive years, and three-fifths in the two following years, so that the central section had a four years' fallow. Numerous samples of ¼ sq. ft. area and 6 in. deep were then taken year by year and reduced in bulk by partly washing through a sieve of such small mesh that even the smallest seeds were retained. The residue from each sample fills an eight-inch pan, and all are kept in a screened greenhouse for at least three years under favourable germination conditions. Every six weeks the seedlings are identified, counted, and removed, and the soil well broken up to bring fresh seeds to the surface.

This method of estimating the number of viable weed seeds by the number of seedlings produced necessitates a long experimental period, but is doubtless more accurate than any method whereby the seed is separated from the soil, counted, and germinated later. The small size of such seeds as poppy and *Gnaphalium* indeed precludes the possibility of any complete mechanical separation.

The original weed seed population, as shown by actual seedlings obtained, was enormous, reaching to over 300 million per acre on one plot, of which 260 million were poppies. The big rush of seedlings appeared within the first three months with poppies and *Alopecurus*, though this did not occur with all species. Fresh seedlings appeared in succession for years, and in some pans which have been kept since 1925 we still get occasional seedlings, even though the conditions for germination have been good throughout. Samples taken in 1925 produced poppies up to 1932, while 1926 samples gave *Anagallis arvensis* and *Aethusa Cynapium* up to 1938, and *Medicago lupulina* to 1936. The preliminary rush indicates that many seeds in the soil are capable of germination if conditions are favourable, but until they are favourable these seeds remain quiescent, in a state that may be called 'induced' dormancy. Other seeds, however, will not germinate immediately under any circumstances, and may be said to be in a condition of 'natural' dormancy. As time goes on these seeds gradually become capable of germination, and their seedlings may appear after several years if they are in a position in the soil which renders germination possible.

These two types of dormancy are more or less paralleled by the condition of seeds in dry storage. Many such seeds are capable of immediate germination if put into suitable conditions, while others will not grow even then. The main difference is that in stored seeds one of the chief factors missing is moisture, whereas in the soil it is some other factor which prevents the immediate germination of seeds that are capable of growing.

After the first rush, germination settles down into a rhythm which varies considerably with species. In perhaps the majority of cases maximum germination occurs in autumn, between October and December ; there is a slackening after Christmas up to March, while during the spring and summer months relatively few seedlings appear. Then, in the autumn, the cycle begins again with a second peak, and a third may follow the next autumn. This is the sequence in an unheated greenhouse, and suggests that after the summer heat a larger proportion of seeds pass out from their state of natural dormancy and are ready to germinate in the autumn. When, however, the experiments are made in a heated greenhouse, two peaks occur each year in autumn, up to Christmas, and late spring, from April to June. This suggests that the subsidiary temperature factor during the winter brings seeds out of dormancy which otherwise would not have been ready to germinate till acted on by the summer weather.

Laboratory experiments on the cause of this periodicity show that it is evidently due to a combination of factors of which temperature probably plays an important part. Fluctuation of temperature seems to be very necessary, as germination of many species, as *Papaver*, was very severely reduced if the soil was kept in a cellar or incubator where the daily fluctuations in temperature were very slight. Species of such genera as *Alopecurus*, however, with a very short period of dormancy and viability, were not so seriously affected by the constant temperature. The reduction of light seemed to be of less importance. Transference of the pans from cellar to glasshouse after a year caused a great rush in the germination of most species.

In a few species, as *Alopecurus agrestis*, the period of dormancy is so short that nearly all the seeds can be worked out of the soil within a year. In others, as *Polygonum aviculare*, there is no preliminary rush, and all germination is delayed until after Christmas, while the numbers appearing in the second year may be much greater than in the first. This particular weed may be said to be very temperamental, for it follows no regular rule. In the field it may be literally knee-deep one year and almost absent the next, and one never knows when it will occur in abundance again. Even in the greenhouse where environmental conditions are controlled and where samples taken in a number of years are under observation together, 'Polygonum years' occur, when this species is relatively plentiful.

The outstanding example of this periodicity, or preference for germination at certain seasons, is *Bartsia Odontites*. Seedlings collected from every soil sample taken show not a single seedling from July to January, followed by a maximum in February to March, tailing off to an insignificant number in June. This may be a selective process due to the incidence of the cereal or grassy host-plants in an appropriate condition for attack between February and May. No other similar instance has been observed.

The relative length of dormancy of different weed seeds may perhaps be judged by the extent to which they are reduced by the intensive cultivation adopted in our greenhouse technique, together with the rate at which they recolonized the soil after the fallow was ended. In the course of two years poppy was only reduced by about fifty per cent., about half the seeds remaining in a state of dormancy. Since the land returned into crop, however, poppies have not tended to increase again. This suggests that many of the seeds have a long period of dormancy and are not ready to germinate very soon after they are shed, so that the ordinary methods of cultivation are now keeping the poppies to the after-fallow level. *Alopecurus agrestis*, on the other hand, was almost eliminated by two years' fallow—the great majority of the seeds came out of dormancy and the seedlings were cut down. The few that remained, however, were prolific in seed-bearing and the seeds, being able to germinate almost immediately owing to their very short period of dormancy (if any), rapidly recolonized the soil until the number of buried seeds present far exceeded that before fallowing.

Similar behaviour was shown by *Stellaria media*. Experiments on similar lines to those described are still going on; but the results already obtained suggest numerous problems which offer an attractive field of investigation, both from the academic and the practical standpoint.

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Discussion.—

Mr. H. N. Ridley said that he had often been puzzled by the appearance of weeds, especially small Euphorbias in his garden, there being no locality for these plants anywhere in the neighbourhood now, and mentioned the sudden appearance of the rare climbing Euphorbiacea *Pterococcus glaberrimus* in the Singapore Botanic Garden when a piece of clay land long abandoned and covered with *Imperata* was dug up. The plant had only been found in the Malay peninsula once before. The ground had been Chinese vegetable land some 25 or more years previously.

Mr. H. R. Darlington said that the lecturer's observation on the desirability of keeping seeds in a moist medium is illustrated by the practice of rose growers, who 'stratify' the seeds, i.e. pack them in layers of moist sand, until the time arrives for sowing them.

Change of temperature seems sometimes to promote germination. A pan of seeds of an Asiatic rose which had failed to germinate in the greenhouse was turned out into the open, exposed to frost and snow, and they germinated freely. Rose seeds allowed to dry are often difficult to germinate.

Professor R. R. Gates said that, among other cultures, he germinated 200 or more seed-pans of *Oenothera* in the greenhouse every year, and was often struck by the differences in germination. Certain species always germinated more promptly than others. Sometimes the results were quite capricious ; two pots of seeds might belong to almost identical strains, the flowers might have been selfed on the same day and the seeds collected at the same time and kept under identical conditions, yet one pot would show a full germination and the other very few or no seedlings. He suggested that possibly some slight difference in pH of the soil might be involved. Many of the Oenotheras also showed delayed germination. A few might germinate in the first two weeks and others keep coming on for the next two months, or a fresh crop would appear when the soil was disturbed by pricking off the first seedlings.

Dr. R. MELVILLE remarked that Dr. Brenchley's experiments were of considerable interest to field botanists. Her results may throw light on the sporadic appearance of some of our rare native plants, such as the Trifoliums that are found at the Lizard in Cornwall. *T. Bocconi*, for example, was very scarce in some seasons and comparatively abundant in others. Erratic germination of the kind exhibited by *Polygonum aviculare* may account for this; had Dr. Brenchley any information on the germination of clover seeds that would clear up this point?

The PRESIDENT stated that air photographs of Stonehenge showed that Saxon fields used to extend right up to the Stone circle. He recalled the fact that Robert Brown had succeeded in germinating seeds of *Nelumbium* at least 150 years after they had come into the possession of Sir Hans Sloane. Dr. Ohga had attempted to germinate seeds of the same collection, but without success. Many experiments had been made on collections of seeds; could Dr. Sprague give any details of some conducted at Kew a short time ago?

Dr. T. A. SPRAGUE referred to a paper on 'The Viability of Seeds' by Mr. J. H. Turner (Kew Bull. 1933, p. 257) containing a summary of previous work on the subject, and the results of germination tests conducted at Kew by Mr. Turner on two sets of seeds, one collected in the Isle of Wight in 1842 by Dr. Bromfield, and the other sent to Kew in 1851 by Peter Lawson & Co. Of these collections, seeds of six species germinated, all belonging to the family Leguminosae.

Ewart (Proc. Roy. Soc. Vict. XXI, p. 199: 1908) divided all seeds into three biological classes: *microbiotic*, with a duration of life not exceeding 3 years; *mesobiotic*, remaining viable from 3 to 15 years; and *macrobiotic*, remaining viable from 15 to over 100 years. 'The macrobiotic seeds . . . are characterized by cuticularized or more or less impermeable seed-coats, and are restricted to a few natural orders [i.e. families], of which the Leguminosae greatly surpass all others while Malvaceae and Myrtaceae come next in importance.'

An analysis by Sprague (Kew Bull. 1933, p. 268) of the 30 families listed by Turner as including species with macrobiotic seeds showed that they belong to only 15 orders. That macrobiotism is an important taxonomic character is evident from the fact that 13 out of the 30 families (43 per cent.) belong to only 3 orders, there being 5 macrobiotic families (i.e. families with macrobiotic species) of Centrospermae, 3 of Malvales, and 5 of Tubiflorae.

Macrobiotism must have great survival value in desert areas where rain falls only at intervals of many years. This is illustrated by the fact that 268 out of 414 Angiospermae (65 per cent.) recorded from the desert of Atacama, Chile, belong to 25 of the macrobiotic families, and only 146 (35 per cent.) to families not known to be macrobiotic.

Similarly, the flora of small sandy maritime islands which is recruited largely by water-borne seeds and fruits include a high proportion of families with an impermeable testa or pericarp, i.e. macrobiotic families: 58 out of 84 species of the Florida Sand Keys (69 per cent.) belong to 19 of the known macrobiotic families.

Dr. Brenchley replied that she had no information by which to throw light on the behaviour of the Cornish clovers; and commented in regard to the record from Stonehenge that if the Saxon fields were arable, and the source of the charlock there, it suggested a very long period of viability for seeds of a *Brassica*.

THE APPLICATION OF BIOMETRICAL METHODS TO THE STUDY OF ELMS.

By Dr. R. Melville, F.L.S.

All biologists are familiar with the phenomenon of variation among the organisms they study and attempt to arrange in orderly manner. In some groups variation, both in similar organs of one individual and the corresponding organs of other individuals regarded as belonging to the same species, is so great as to lead to difficulties in their classification. This is especially true of our native elms in regard to their leaves.

In the genus *Ulmus* the flowers are small and present a relatively small number of variable characters on which a classification can be based. The fruits also are comparatively simple. On the character of these the classification of the species in the genus has been based mainly, and to a great extent it has ignored the characters of the foliage. This is no doubt due to the difficulties of employing the characters of such variable organs as their leaves. It is only by the application of new methods that this variability can be turned to advantage and used for classificatory purposes.

It may be well to review here, briefly, the types of variation encountered in the leaves of our elms. The normal branches forming the crown of a tree consist mainly of two kinds of shoot: (i) long vigorous shoots terminating the principal branches and bearing a variable number of leaves, and (ii) short lateral shoots that normally bear only four or five leaves. In some seasons when the normal foliage has been damaged by late frosts, high winds or some such cause, both kinds of shoot mentioned renew their growth and produce leaves differing in shape and degree of hairiness from the normal leaves. Such shoots are known as proleptic shoots. In passing from base to tip of the shoot there is a transition in shape from that of the normal foliage to some other distinctive shape, either shorter and broader or longer and narrower, in particular forms. The nature and sequence of these changes in form are characteristic and of taxonomic value. Around the base of the tree sucker-shoots are frequently found. The leaves of these differ in shape from those of normal shoots and are always very rough and hairy. They resemble the leaves of seedling plants and represent a reversion to a juvenile form. On the bole of the tree, especially if branches have been lopped, other shoots, the epicormic shoots, are often present. These bear foliage intermediate in shape and hairiness to varying degrees between that of the sucker-shoots and the normal foliage.

Of all the different kinds of shoot, the normal short shoots of the crown exhibit least variation both on the individual tree and among trees of one kind. There is a regular sequence in form between the leaves of a short shoot from base to apex. The nature of this sequence and the particular shapes of the leaves are characteristic in different species and forms. Hitherto, largely on account of the difficulty of describing the subtle differences between such closely similar shapes, practically no use has been made of these form-characters in the classification of the elms, or, for that matter, of corresponding types of variation in other groups.

In addition to the variability of individuals and single species outlined above, is the variability introduced by hybridization and subsequent segregation and back-crossing. This results in the formation of a series of intergrading forms connecting the species and obscuring their limits. I noticed that the shapes of leaves from corresponding positions on the short shoots of individual trees varied relatively little, but the differences in shape between the corresponding leaves of trees of other forms, though appearing to be significant, were incapable of definition in words. If some method of accurately defining these differences could be found then advantage could be taken of variations in leaf-shape for the purpose of classification. This led me to examine the possibility of defining leaf-shapes by means of rectangular co-ordinates, for it is obvious that any shape, however complex, could be defined in that way. Limits would be set only by convenience and the patience of the worker.

After first trying out a mechanical method, the optical method now in use was adopted. Briefly it consists of making outline drawings in Indian ink on grease-proof paper of the leaves to be measured and projecting the drawings by means of a photographic enlarger on to a measuring grid. The grid is divided into ten squares in each direction. The leaf midrib is arranged along the central line of the grid and the lamina enlarged to extend the full length of the scale. Using the central line as a line of reference, co-ordinates are read for points on the outline at each intersection up the length of the grid for each side of the leaf. The readings are in percentages of the length, so that measurements from leaves of any size are comparable with one another and average co-ordinates from a series of leaves can easily be obtained. The differences between two sets of averages can be tested statistically for significance if desired. The method was described in a paper in the 'Annals of Botany' (N.S. I, pp. 673–80; 1937).

It is important when applying a biometrical method such as this, that the organs to be compared should be truly comparable with one another. This object is attained by using for measurements only normally developed, fully grown short shoots and comparing only leaves from corresponding positions—distal leaves with distal and subdistal leaves with subdistal. In practice ten short shoots from each tree have been used for measurement and average co-ordinates obtained for distal and subdistal leaves. Differences of two to three units for corresponding points between two sets of means have been found to be significant in examples tested. This quantity represents 2 to 3 per cent. of the length of the lamina. The mean outlines are surprisingly good considering that only ten leaves have been used to obtain each one. An unexpected deviation of one unit on the outline has several times revealed an error of addition in calculating the means.

Some time after this method had been worked out my attention was drawn to a paper by Lindquist on the varieties of the Wych Elm, *U. glabra* Huds. (Acta Phytogeographica Suecica, IV, 1932). In this paper he describes as new two varieties, var. *scabra* and var. *montana*, to which I shall refer again later, and also gives mean outline shapes for half leaves. Some of these outlines appear to be, and probably are, a combination of at least two outlines, either of the short side and long side of similar leaves or of corresponding sides of leaves of different form. The irregularities observed are no doubt artefacts dependent on the method used, which was as follows. The leaves of a tree were sorted out into groups differing by 1 cm. in length. Measurements of breadth were made at a number of corresponding levels up the lamina for each size-group and means obtained. Twenty or more leaves were used for each size-group. There are two very important disabilities in this method that make it of very little value for critical work. First, no account is taken of the difference in form of the long and short sides of the asymmetrical leaves. If an accurate outline is to be obtained long sides must be compared only with long and short sides with short. Secondly, by sorting into size-groups, leaves from various positions on the shoots are brought together in disregard of the fact that the shape varies with the position of the leaf on the shoot. Both of these sources of error are avoided by the method I have adopted.

As an example of the application of rectangular co-ordinates to the exact definition of leaf-shapes the varieties of *Ulmus stricta* Lindl. may be used. The type variety, var. *cornubiensis* (Loud.), has the narrowest leaf, with the base wedge-shaped and narrow on the long side of the leaf. This feature is especially well marked in the distal leaves of the short shoots. This variety occurs as a wild tree throughout Cornwall and Devon and into Dorset. It is a tall tree with rather short, stiff, spreading lower branches and the upper branches steeply ascending. The Hampshire variety, var. *Goodyeri* Melville, has broader leaves with the base on the long side, much broader than in var. *cornubiensis*. The Goodyer Elm is a much more spreading tree than the true Cornish, not so tall and with relatively longer branches. The Jersey or Wheatley Elm, var. *sarniensis* (Loud.) Moss, is the third of this series and is supposed to be a native of the Channel Islands. The leaves are broader than in either of the other varieties, and the base, on the broad side, is also somewhat broader on the average than in var. *Goodyeri*. The habit is pyramidal, with the lower branches rather long and spreading and the upper shorter and rather steeply ascending.

These leaf-shapes form a graded series (fig. 1), and if the Wheatley Elm is in fact a native of the Channel Islands, successive members of the series are situated in their correct order along a line running roughly west to east. The varieties of *U. stricta* therefore form a cline in Huxley's sense, as the series has a geographical basis. The shapes of the leaf-serratures also form a sequence along the same cline. In var. *cornubiensis* the teeth are very blunt, with one or occasionally two secondary serratures; var. *Goodyeri* has somewhat sharper teeth, with two or sometimes one or three secondary serratures; var. *sarniensis* has the sharpest serratures of the three forms, and three or sometimes two secondary serratures. These remarks apply to the most highly developed teeth, those at the base of the shoulder of the leaves, about two-thirds of the length of the lamina from its base. Mean shapes of such teeth from the long side of subdistal leaves of the short shoots were obtained by a slight modification of the method used for leaf-shapes. The short shoots were placed in the enlarger and the enlarged outline of suitable teeth drawn in Indian ink on 'grease-proof' paper, one tooth from each of ten short shoots. A line was drawn across the base of each tooth connecting the adjacent sinuses and a smooth outline drawn across the secondary serratures The outlines were then placed in the enlarger and projected on to a measuring grid, the scale being adjusted so that the base-line occupied 100 units and was lying parallel to the base-line of the grid. The tip was placed on the base-line of the grid and coordinates read off at suitable intervals ; inversion of the teeth avoids complications due to differences in height By the application of this method differences in the serratures of the leaves can be defined accurately as well as the leaf-shapes themselves.

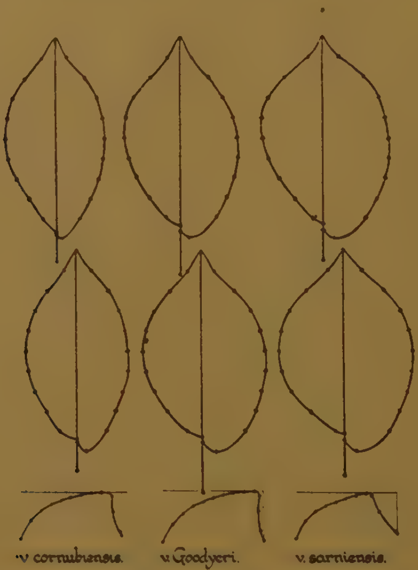

FIG. 1.—A cline in *Ulmus stricta* Lindl. Each vertical row illustrates one variety. Horizontal rows :—Top : mean shapes of distal leaves ; middle : mean shapes of subdistal leaves bottom : mean shapes of typical leaf-serratures.

Another field in which these biometrical methods have proved useful is the rational arrangement of hybrid swarms The intergrading forms connecting a pair of species and derived by hybridization, segregation, and back-crossing are difficult to classify by the usual methods. It is sometimes difficult to find two hybrid trees alike, though of the same parentage The taxonomist is driven either to select arbitrarily a few relatively distinctive forms for description and ignore the rest or to leave the whole problem severely alone. Among the elms such intergrading hybrid swarms can be arranged in series by making use of differences of leaf-shape. Series of this kind may be regarded as clines, though they are not clines in Huxley's sense, as their members are scattered at random and have no definite geographical relationships. It is convenient to have a term to describe this sort of cline, and the term *nothocline* (i.e. hybrid-cline) is here proposed. By the use of biometrical methods, therefore, it is possible to define a nothocline with some degree of accuracy, and the need for description of all the individual members of any intergrading series of hybrid forms disappears. As a matter of convenience it is advantageous to describe a limited number of forms from different parts of a nothocline to serve as points of reference in assigning intermediate forms to their correct places. Here again a new term is required to take the place of 'variety' or 'form', the use of which for hybrids has been objected to in some quarters. Both of these terms have been much abused, and are better avoided when special significance must be attached to their use. I therefore propose the term

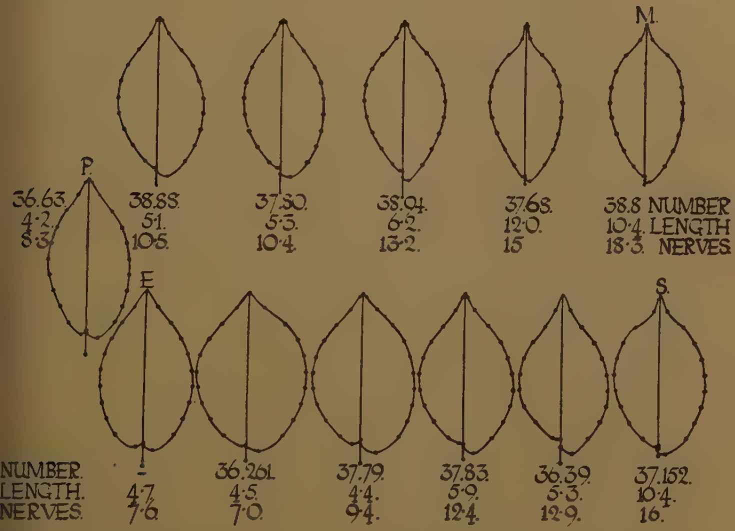

FIG. 2.—Nothoclines between *Ulmus Plotii* Druce and *U. glabra* var. *montana* Lindq. and *U. glabra* var. *scabra* Lindq. All outlines represent mean shapes of subdistal leaves of short shoots. P, *U. Plotii*; M, *U. glabra* var. *montana* Lindquist; S, *U. glabra* var. *scabra* Lindquist; E, × *U. elegantissima* Horwood. Number=Author's field-number. Length=mean length of lamina in cm. Nerves=mean number of main lateral nerves on long side of leaf.

nothomorph (nothomorphus=hybrid form) for all hybrid forms of sexual origin, whether F_1, segregates or back-crosses.

As an example of a nothocline the forms intergrading between *Ulmus glabra* Huds. and *U. Plotii* Druce may be taken. Lindquist has described two varieties of *U. glabra* (Rep. Bot. Exchange Club for 1931, IX, p. 785; 1932), var. *scabra* with broadly ovate leaves (fig. 2, 37.152) and var. *montana* with lanceolate to ovate-lanceolate leaves, with narrower apex and thicker in texture (fig. 2, 38.8). Both of these varieties occur in England, and there are forms intergrading between the two extremes within the species. Forms of the var. *scabra* with relatively broader and more orbicular leaves than that of the tree illustrated here also occur. Characteristic features of *U. glabra* are the broad rounded head with spreading lower branches and often several ascending upper branches, the stiff, rather thick (1 year old, 2–3 mm.) branchlets, and rufous hairs on the bud-scales. The other parent of this nothocline, *U. Plotii* (fig. 2, P), is a tall, slender tree with a single trunk, and often with the tip drooping over gracefully. The branchlets are long, slender (1 year old, 1–1·5 mm. thick) and pendulous. The leaves are small, about 4 cm. long, and have a subequal cordate base. Actually the nothocline is double, as there are forms intergrading between both varieties of *U. glabra* and *U. Plotii*; that is, there exists a broad-leaved and a narrow-leaved series.

To discuss the broad-leaved series first, closest to *U. Plotii* in leaf-shape of the forms I have examined comes *U. elegantissima* Horwood ('Flora of Leicestershire', 1933, p. 482). The leaf-outline (fig. 2, E), was calculated from tracings of five subdistal leaves on the type-specimen in the National Museum of Wales. Horwood informed me that his elm was common in the area about Tilton and Launde in Leicestershire, but when I visited the district in 1936 I found only one tree that he agreed was *U. elegantissima* among a number collected. This tree is evidently a hybrid of *U. glabra* and *U. Plotii*. The habit is closer to that of *U. glabra*, but with the branchlets somewhat pendulous and the leaf-shape nearest to that of *U. Plotii* (fig. 2, 36.261). It appears to match Horwood's type-specimen except that the leaves are on the average slightly broader. The next two members of this series (fig. 2, 37.79 and 37.83) are from the area in Leicestershire in which Horwood said *U. elegantissima* was common; No. 37.79 from Kibworth Harcourt is an upright tree with rather stiff branchlets, though more slender than in *U. glabra*: No. 37.83 from Halstead is an upright tree with somewhat pendulous branchlets. The next member (fig. 2, 36.39) is a roadside tree from near Sturdy's Castle on the Oxford—Banbury road; its general habit is that of *U. glabra*, but the outer branchlets are distinctly pendulous.

The member of the narrow-leaved series placed nearest to *U. Plotii* (fig. 2, 38.88) is a tall tree recalling the habit of Plot's elm, but less pendulous and more densely branched. It was collected near East Stoke, Notts., at a spot where both parent species were growing within a short distance. The next (fig. 2, 37.80) is again from Kibworth Harcourt, an upright tree rather densely branched and not pendulous; then follows a tree (fig. 2, 38.94) from a district in which *U. Plotii* is common, between Stapleford and Brant Broughton in Lincolnshire. This had the habit of *U. glabra*, but was more densely branched, and the short shoots exhibited a tendency to elongate as they do in *U. Plotii*. The leaves of the proleptic shoots, also, are very similar to those of *U. Plotii*, but larger. The last intermediate (fig. 2, 37.68) grows at Banbury near the Plot's elm illustrated, and resembles *U. glabra* var. *montana* in almost every way except that the distal frequently and the subdistal leaves less frequently have a subcordate base as in *U. Plotii*. The outer branchlets, also, are slightly pendulous.

From the foregoing it appears that habit-characters do not run parallel with the leaf-shape characters on which the nothocline is based. This was to be expected, since it is unlikely that habit-characters would be linked with those of leaf-shape. Lack of correlation with other characters, however, does not detract from the value of arranging hybrid swarms into nothoclines, for unless a large number of characters were closely linked in the plant the choice of criteria on which to base any such systematic arrangement must of necessity be arbitrary. Nevertheless, there is quite good correlation between leaf-shape and both the length of the lamina and the number of main lateral nerves. It can be seen from fig. 2 that the means for these characters fall into line with the nothocline based on leaf-shape. That the number of main lateral nerves is very closely correlated with the length of the lamina is evidenced by the data. In the series here considered the mean spacing of the lateral nerves varies only from about 5 to 6 mm. The evidence, such as it is, suggests that the factors governing leaf-length, number of lateral nerves and leaf-shape are all closely interlocked. From a preliminary examination of the indumentum it is probable that such characters as numbers of glands and of simple hairs per unit area of leaf-surface and lengths of the simple hairs are similarly correlated. It will be of great interest to determine whether such correlations exist in other nothoclines in *Ulmus*.

In conclusion it may be pointed out that × *Ulmus elegantissima* (Horwood), hybr. nov., is the binomial under which all the hybrid forms mentioned in this paper must be placed. A selection of the forms of this hybrid will be described more fully later.

PROCEEDINGS OF THE GENERAL MEETING
13 APRIL 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President,
in the Chair

The Proceedings of the General Meeting held on Thursday 16 March 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Clarice Vivian and Albert Pam.

A certificate of recommendation of the following candidate for Fellowship was read :—For the second time, in favour of Ivan Robert Dale.

Certificates of recommendation of the following candidates for Foreign Membership were read for the second time :—Alfred Ernst, William Albert Setchell, Alfred Rehder, Willem Marius Docters van Leeuwen, and William King Gregory.

A certificate of recommendation of the following candidate for Associateship was read for the first time :—John Ardagh.

The President announced that the Council had resolved unanimously to award the Linnean Gold Medal for 1939 to Dr. Elmer Drew Merrill, F.M.L.S.

Miss R. F. Shove, F.L.S., exhibited and gave an account of ‘ Viability of the spores of *Funaria hygrometrica* ’. [Printed in full below, p. 161.]

Dr. Hugh Scott, F.L.S., gave an account, illustrated with numerous lantern-slides, ‘ Some general considerations regarding the natural history of the Western Aden Protectorate and the Yemen ’. [Printed below, p. 164.]

Dr. F. C. Fraser (Visitor) gave an account, illustrated with lantern-slides, of ‘ Three strange Irish Dolphins ’.
Mr. M. A. C. Hinton added some comments.

THE VIABILITY OF THE SPORES OF FUNARIA HYGROMETRICA.

By Miss R. F. Shove, F.L.S.

The spores of some mosses are known to retain their viability over a considerable period of time, thus Chalaud states that the spores of *Sphagnum* will germinate three years after their collection, and Schimper records that the period of viability of certain mosses may last as long as fifty years ('Manual of Bryology', edited by Verdoorn). The following investigation shows that the power of germination is retained for several years by the spores of *Funaria hygrometrica*.

The *Funaria* spores used in this experiment were collected in 1927 from Oxshott Common, in 1933 from Bedgebury Park, in 1936 from Aberystwyth, and in 1937 from a greenhouse culture. The spores were sown under four different conditions: (1) on unsterilized garden loam, (2) on sterilized loam, (3) on sterilized sand, and (4) on damp blotting paper. All the cultures were covered by glass to prevent so far as possible the entry of spores of other organisms, and each culture received the contents of one well-developed capsule. When the spores were cultivated on soil or sand the viability was roughly estimated by the thickness of the protonemal layer produced, but when they were sown on filter paper it was possible by a count to estimate the percentage number that germinated in a certain time.

Experimental results.

(1) The 1937 spores have shown complete viability under all cultural conditions up to the present time.

(2) The 1933 spores germinated freely from the date of collection until the autumn of 1938, when counts of those sown on filter paper showed that only about 25 per cent. had developed. The spores sown at that time on sterilized soil and sand produced healthy protonema on which sporogonia formed in the following spring.

(3) The 1927 spores have been cultivated continuously from 1930 until the present time. In the earlier cultures on unsterilized soil the spores germinated freely and the plants developed sporogonia in the years after sowing. Later cultures on sterilized sand and soil produced thinner protonemal layers. The spores sown in the autumn of 1938 formed no visible protonema until the spring of 1939, when the soil began to show green coloration and microscopic examination of the soil revealed a few protonemal filaments. All the spores on filter paper and sand failed to germinate. It is therefore clear that the viability of these *Funaria* spores had much diminished by the end of eleven years, but that under favourable conditions a few were able to develop.

Spore structure and germination.

The spores of *Funaria hygrometrica* are spherical, about 10–15 μ in diameter and covered with a thick reddish-brown coat. Each contains a highly refractive mass (nucleus ?), granular protoplasm and numerous oil drops (fig. 1). During germination the contents of the spore swell considerably, the extine cracks, the refractive mass and the oil drops disappear and small chloroplasts make their appearance; the cytoplasm covered by the intine grows out to form a cell rich in chloroplasts, which develops into the usual protonemal filament. Young spores germinate under favourable conditions in three or four days.

Microscopic examination of 1927 spores failed to show any marked difference between their structure and that of younger spores. Some shrinkage in size was apparent and the refractive mass was usually larger and more irregular in outline than in 1937 spores, but there was no apparent cause for the diminution in viability.

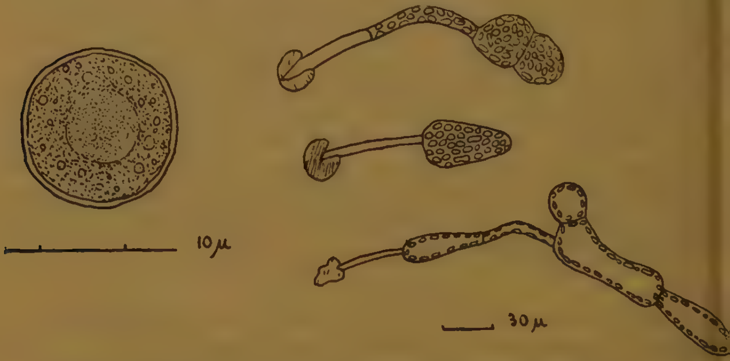

Fig. 1.—On the left, a spore of 1937. On the right, abnormal protonema, Nov. 8th, 1937, to April 11th, 1938.

Observations on development.

The leafy plants usually just produce sporogonia in the year that follows the germination of the spores, but the plants from younger spores show greater vigour and produce sporogonia several weeks earlier than those from older spores. Thus in March 1938 and 1939 the plants from 1936 spores which germinated in 1937 had pendent pear-shaped capsules whereas those from 1933 and 1927 spores still showed slender erect capsules.

A further matter of interest connected with development is shown in protonema cultivated on damp filter paper. The spores germinate in the usual way, but fail to produce typical, slender, branched protonema; they develop short filaments of which the terminal cells are swollen and distorted (fig. 1, on the right). This abnormal growth has been described by Goebel (' Organography of Plants ', fig. 104), who attributes it to unfavourable environmental conditions. When the protonema develop on filter paper supplied with ordinary tap-water this condition may be lack of mineral salts.

Another abnormal protonemal form has been observed in which the modification appears to have gone a stage further. The filter paper culture shows numerous large globular cells, rich in oil drops and chloroplasts, which multiply by elongating slightly and then cutting off the terminal portion by a cross wall; this part then separates and repeats the process (fig. 2). The globular cells, when transferred to damp soil, in a few days produce typical protonema.

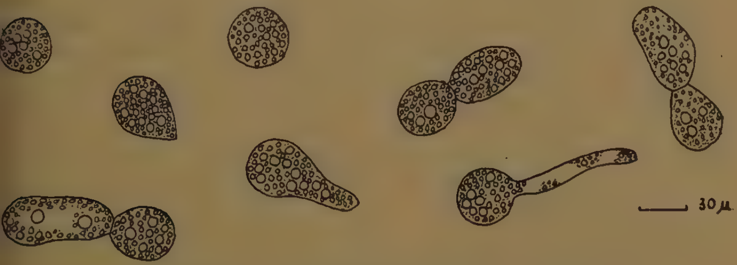

Fig. 2.—Abnormal protonemal cells, Nov. 27th, 1938, to March 11th, 1939.

A somewhat similar phenomenon is described by Goebel, who states that ' In *Funaria hygrometrica* colourless limiting cells whose walls become partly mucilaginous appear between the ordinary green protonemal cells and bring about a separation of these cells which remain alive. The biological significance of the process is chiefly to be found in the fact that the isolated cells can more easily again attain to favourable conditions ' (*ibid.* p. 262).

LITERATURE CITED.

Chalaud, G. 1932. Germination des Spores et Phase Protonémique. Manual of Bryology, ed. by Fr. Verdoorn.
Goebel, K. 1905. Organography of Plants.

The President congratulated Miss Shove on her interesting work and stated that from his experience with the spores of fungi he anticipated that yet longer viability may be demonstrated by her.

SOME GENERAL CONSIDERATIONS REGARDING THE NATURAL HISTORY OF THE WESTERN ADEN PROTECTORATE AND THE YEMEN.

By Hugh Scott, Sc.D., F.L.S.

In the following pages an account is given of certain aspects of the natural history of the Western Aden Protectorate * and the Yemen, such as were not particularly emphasized in the article on the British Museum (Natural History) Expedition entitled 'A Journey to the Yemen', and printed in the 'Geographical Journal' (vol. xciii, pp. 97–125, Feb. 1939).

As a result of this Expedition, undertaken by the writer and Mr. Everard B. Britton, M.Sc., from September 1937 to March 1938, about 27,000 insects and some hundreds of other invertebrates (Crustacea, Arachnida, land and fresh-water Mollusca) were collected in this area hitherto almost entirely unexplored from this standpoint. Even among the plants the nearly 600 specimens included many species of which no examples had been received by the Botany Department since those collected in 1763 by Forskål, a pupil of Linnaeus and member of Niebuhr's ill-fated expedition, were acquired by the Museum with the herbarium of Sir Joseph Banks after 1820.

The highlands of the western division of the Aden Protectorate and of the Yemen have abundant summer monsoon rains and are very fertile. In the low coastal plains the rains are less regular, often at very long intervals, and sometimes in the winter months. The hot valleys, torn in the southern and western edges of the high plateaux, have a largely tropical fauna and flora, with a strong African, but also an Oriental, element. On the high plateaux and mountains there is an admixture of Palaearctic forms. Thus, these countries lie in an area where three great bio-geographical regions interlock. Further, the Yemen highlands have been only recently sundered by the Red Sea from the corresponding elevated areas in Eritrea and Ethiopia. A desire to compare the faunas of the two sets of highlands was a strong motive for undertaking the journey.

As regards the geological structure, one writer considers this very highly raised Yemen–Abyssinian block, divided by the Red Sea rift, as a separate structural element lying

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* The 'Western Aden Protectorate' is an administrative division of the British Protectorate, comprising various sultanates, amirates and other tribal territories. It is distinct from the eastern division, which includes the Hadhramaut. The name is used as a convenient term to cover those areas outside the independent kingdom of the Yemen in which the Expedition worked.

between two great massifs of ancient crystalline rocks, the Arabo–Nubian (also cut across by the Red Sea rift) and the Arabo–Somali (cut across by the Gulf of Aden). The Yemen–Abyssinian block lies at the meeting-point of three great trough-faults, namely the Red Sea, the Gulf of Aden and the East African rift *.

Even if these views on the general structure of the region be regarded as rather abstruse, more detailed information about the geology of the south-western corner of the peninsula can be briefly given. In the Yemen the stratigraphical series overlying the ancient crystalline rocks begins with the Jurassic. Above this is a series of sandstones of the Cretaceous, penetrated by volcanic necks and overlaid by a great thickness of trap, the outpouring of which is assigned to late Cretaceous or early Tertiary time. Round San‘a the work of the expedition was carried on among landscapes formed by the Cretaceous sandstones and the trap-series. The later volcanic deposits are separated from the trap-series by a long interval of time, during which the sinking of the Red Sea rift and of the Gulf of Aden is believed to have occurred †. These comparatively recent volcanic outpourings are believed to have begun in the later Tertiary (possibly Pliocene) and have continued into historic times. Indeed, hot-springs exist in many parts of the country at present, as at Huwemi in the Aden Protectorate, and Hammam Ali, in the Yemen between San‘a and Hodeida, to mention only two, which the writer personally visited ; while volcanic cones and scarcely weathered basaltic lava-flows are the main constituents in the scenery of certain districts, such as that of Huqqa, which forms the southern part of the ‘ Harra ’ of Arhab, north of San‘a, and which was the northernmost point reached by the Expedition. Several phases of eruption have been distinguished in this recent volcanic series, of which certain of the islands in the Red Sea, the Aden Peninsula itself, and volcanic formations along the coast to the west of it, as well as in the Eritrean coastal region, form part.

Mention must also be made of the aeolian deposits forming San‘a plain, at little under 8,000 ft. above sea-level. These deposits are described by Rathjens and von Wissmann as ‘ subdiluvial ’ and as resembling typical loess, though of

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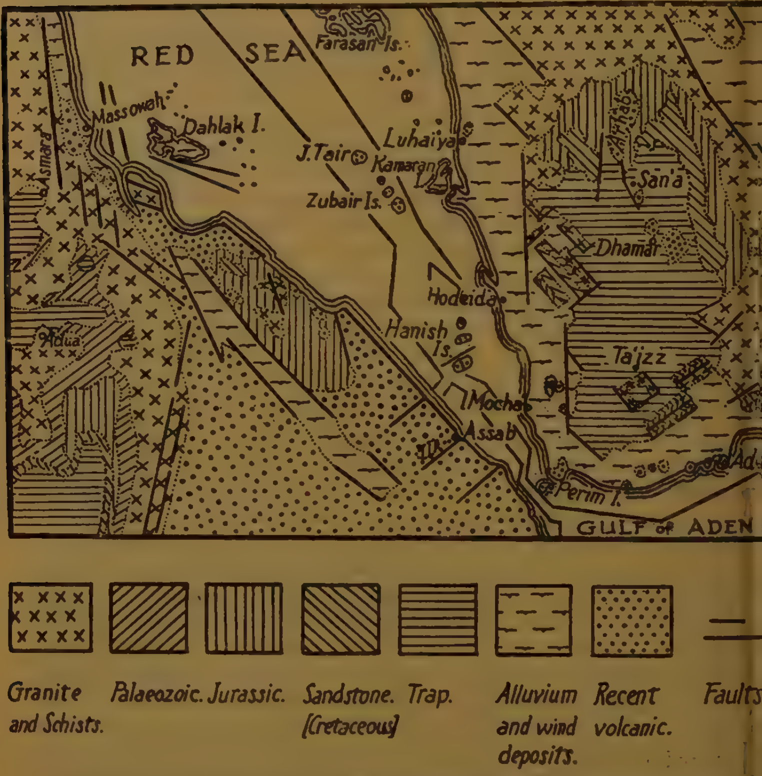
* L. Picard, ‘ On the Structure of the Arabian Peninsula ’, Hebrew University Geological Department, Jerusalem, Ser. I, Bull. 3, 1937.

† For the statements in this and the following paragraph see the chapter entitled ‘Die geologischen Verhältnisse des in Jemen bereisten Gebietes ’ in Rathjens and von Wissmann, ‘ Süd-Arabien Reise ’, II, 1934, pp. 154–76 (Hamburgische Universität, Abhandlungen aus dem Gebiet der Auslandskunde, vol. XL). See also H. von Wissmann, Übersicht über Aufbau und Oberflächengestaltung Arabiens’, in Zeitschr. Gesellsch. für Erdkunde zu Berlin, nos. 9, 10, pp. 335–57, 1932.

coarser grain; these authors also regard their formation as having taken place under drier climatic conditions than those now prevailing. The aeolian deposits are very porous and rapidly absorb rain-water, whence the numberless wells of San'a and the outlying towns and villages. The material for the bricks of which the old walls and large parts of the buildings of San'a are constructed is dug from the same deposits. The low-lying coastal belts of desert known as the Tihama are also partly of aeolian formation.



Diagrammatic Sketch-map showing similarity of the main geological features on either side of the southern end of the Red Sea. Scale 1 : 7,500,000. (Adapted from H. von Wissmann; some of the lesser faults are omitted, and the aeolian deposits round San'a are not indicated.)

Further south, in the Western Aden Protectorate, the block of high tablelands is much broken up into mountain-masses and chains, the geology of which cannot be detailed here.

As to the tectonic aspect, the authors cited (i.e. Rathjens and von Wissmann) distinguish three main series of faults in all this region, namely (i) an Eritrean series, running approximately south-south-east to north-north-west, or parallel to the direction of the Red Sea, (ii) a meridional series, running north and south, and (iii) an Aden series, more nearly east and west. Some faults of each of these series are indicated in the sketch-map. These writers emphasize that the Yemen high plateau is not merely the bent-up, broken-off edge of the Arabian land-mass, but a real tectonic uplift, falling away along lines of faulting on the east towards the desert and on the west towards the Red Sea; and that the Abyssinian elevated block has the same tectonic character, possessing a fault-margin on the western as well as on the eastern side. They consider that the formation of faults of the SSE.–NNW. series began after the mighty outpouring of trap which had ended in the earlier part of the Tertiary, that the development of 'land-steps' set in along the edges thus formed, and that the great sinking of the Red Sea rift belonged to a much later phase. The most impressive recent volcanic outbursts appear to have occurred, in the Yemen at any rate, in districts which were less disturbed tectonically—the opposite of what might have been expected.

In so far as the geological history of the region expresses itself in terms of present-day altitude, soil-composition, and climate, there is at least a broad correlation between it and the present distribution of fauna and flora. How far this correlation extends to lesser geological features, or depends on the relative ages of geological formations, is more difficult to determine.

Such is a slight geographical and geological sketch of the country in which two separate journeys were made. The first (September to November), to the Dhala highlands of the Aden Protectorate, about sixty-five miles north of Aden, comprised stays at the town of Dhala itself, on a fertile plateau 4,800 ft. above sea-level; over a month's camping at 7,100 ft. on top of Jebel Jihaf, a great massif of igneous rock rising to over 7,800 ft.; a rough scramble down 3,000 ft. of its north-western face to the vast and broad chasm in which runs the Wadi Tiban at about 3,800 ft.; and a long trek to Jebel Harir, a sandstone mass reaching 7,700 ft., with a sloping table-top mainly of bare rock, approached by a narrow valley in the mountains east of Dhala. The route of the second journey (December to March), for which a fresh start was made from Aden, was north-westwards, crossing the Yemen frontier in Wadi Natid, to Ta'izz, chief city of southern Yemen, at 4,500 ft., where a stay of nearly three weeks was made; here a height of nearly 7,000 ft.

was reached in the narrow valleys furrowing the slopes of Jebel Sabir. From Taʻizz the Expedition continued northwards through the central Yemen highlands, *viâ* Ibb, Yarim and Dhamar, to Sanʻa— a journey which entailed crossing three passes, at over 8,000 ft., between Taʻizz and Ibb, at 9,700 ft. on the Sumara pass between Ibb and Yarim, and about 9,600 ft. on the range lying across the plateau nearly 30 miles south of Sanʻa. More than two months were spent in Sanʻa, during which many places in the immediate vicinity of the capital and within a day's journey were visited, and longer journeys of several days were made to the north (Huqqa and Haz, including the southern part of the volcanic Harra of Arhab mentioned above, and the ascent of Jebel Kohl, an extinct crater, 9,500 ft.) and to the south-east (Ghaiman and the slopes of Jebel Girwan). Finally, early in March, the route towards Dhamar was retraced as far as Maʻbar, over thirty miles south of Sanʻa, whence a descent was made into the hot and luxuriant valleys running westward towards the Red Sea; the last stages, some thirty miles across the desert Tihama, led to the town and port of Hodeida.

Vegetation characteristic of many altitudes was met with on these journeys. For instance, maritime plants (*Suaeda* etc.) are found near the coast, and a specially rich growth of these, together with branching fan-leaved doum-palms (*Hyphaene*) was seen on sand-dunes near Hiswa on the north shore of the bay of Aden. Lahej oasis, on the lowland plain twenty-seven miles north of Aden, is characterized by millet-fields, groups of date-palms, plantations of banana, paw-paw trees and many other tropical plants. North of this, in the foothills, the wadi beds are fringed with tamarisk, the slopes bear more or less scanty thorn-scrub, consisting of acacia, wild vines (*Cissus*), *Calotropis procera* and other plants. A smaller form of millet (*Pennisetum* sp., duhn or 'bulrush-millet') was also seen in fields up to between 2,000 and 2,500 ft. On Dhala plateau most cultivable ground is occupied by the tall 'white millet' or dhurra (*Sorghum* sp.), also grown in some places at lower altitudes, as well as much higher, e.g., on top of Jebel Jihaf and on the high plateaux of the Yemen; the cultivated land is dotted with spreading ʻilb trees (*Zizyphus Spina-Christi*) and wild figs; stony, uncultivated places bear rather low-growing succulent euphorbias; while shady gorges, such as Wadi Dareija, south-west of Dhala, with perennial streams, are filled with a luxuriant growth of wild fig trees, branching prickly-leaved *Acanthus* (*A. arboreus*) and many other plants, including arborescent aloes on tall pole-stems (probably *Aloe sabaea*). On Jebel Jihaf dhurra predominates on the stone-terraced fields up to well over 7,000 ft.; wheat and barley are also grown, and all these cereals are harvested in September. Cultivation here also includes irrigated beds of onions, fields of chick-peas and other Leguminous crops, and at least one small coffee-plantation. Rocky and waste places are covered with a great variety of plants which were flowering at and after the ending of the rains. Among the more showy were several species of *Barleria*, an orange-flowered *Gladiolus* and a bush-*Senecio* reaching a height of over 6 ft. in some cases. Among rock-plants, *Dianthus uniflorus* was found at an altitude of 7,500 ft., but was afterwards seen in the Yemen up to over 9,000 ft.; a creeping campanula (probably *C. edulis*) and *Swertia polynectaria* were also found in spots near the summit of Jebel Jihaf where shade and moisture are greatest, mainly at the foot of cliffs facing north-west, and these species were also afterwards seen at higher altitudes in the Yemen. *Primula verticillata* occurred beside waterfalls in a narrow gorge at 6,500 ft., a plant later seen in similar situations up to 8,000 ft. Succulent euphorbias were also abundant on top of this mountain, including a tall candelabra-like species (*E. Ammak* ?) often grown as hedges round enclosures near houses.

In Wadi Tiban, north-west of Jebel Jihaf, the vegetation is mainly a sparse dry scrub, with rank growth in the hollows. Swollen-stemmed Adenium-bushes (probably *A. obesum*), up to about four feet high, were leafless but in full flower in late October; individual plants were afterwards seen in flower up to December at least, and some very much taller; for instance, a specimen over ten feet high was seen in the low country west of Ta‘izz. Small bushes of a species of *Indigofera* in the valley of the Tiban river yielded, when shaken, several species of weevils and Hemiptera never taken apart from this plant, and the same insects were always subsequently found on *Indigofera* in other places, up to an altitude of about 4,500 ft. near Ta‘izz. On the banks of the Tiban river, and also in deep narrow wadis at the foot of Jebel Harir, grew dense thickets of a dwarf palm (*Phoenix reclinata*) with very short stems. *Centaurea maxima*, a giant bush-knapweed reaching six to eight feet, with purple flower-heads and foliage silvery beneath, was first met with on the steep slopes of Jebel Harir.

Much of the steep slopes of Jebel Sabir, immediately south of Ta‘izz, is given up to intensive cultivation in terraced fields of qât (*Catha edulis*), a small tree grown for the sake of the stimulating drugs contained in the foliage. In waste places among the terraces *Rosa abyssinica* still displayed a few white flowers in late December, and a trailing *Clematis* was then in full bloom. On the journey northwards to San‘a country covered by a variety of succulent euphorbias and aloes was traversed, especially on the first stage, between Ta‘izz and Saiyani. A patch of *Iris albicans*, displaying a few scented white flowers at the New Year, was found at Menzil Sumara (about 8000 ft.); this iris was also planted on graves in the local burial ground, a custom said to be widely practised by the Arabs, and to have possibly influenced the distribution of the plant, which occurs from western Mediterranean lands to the Yemen.

North of the Sumara pass the Central Yemen plateau at altitudes between about 8,000 and 9,000 ft. was mainly a patchwork of bare ploughed fields in early January. Scrub-juniper a few feet high was photographed at a point just below 10,000 ft. on the north slope of the range nearly 30 miles south of San‘a; some isolated juniper-trees, reaching a height of about fifteen feet, had already been seen in an uncultivated valley in Jebel Sabir near Ta‘izz, at about 6,000 ft. These were the only conifers met with on the whole journey.

An amenity of San‘a and its environs, constituting also an important source of local produce, consists of the apricot, peach and walnut orchards situated at points where springs issue from the rocky mountains some miles west and north-west of the city. Apricot- and peach-trees were in full bloom at the end of January, while walnut-trees were still bare. Apart from these orchards and the cultivated plain round the city, waste places and mountain sides in the San‘a district are stony and nearly bare, with a sparse growth of low plants, among them the succulents which reach the upper limit of distribution for such plants in altitude, at about 9,000 ft.; namely, *Euphorbia officinalis*, which forms a compact, prickly, pin-cushion-like mass only about a foot high, a low-growing Asclepiad (*Stapelia* sp.) and a few aloes *.

On the journey down to Hodeida the zones of vegetation corresponded on the whole with those on the route northwards from Aden. Two facts may, however, be mentioned. In the broad valley in which lies Madinat al Abid (probably somewhat below 4,000 ft.) are several small but dense patches of high forest-trees, wild figs and Leguminosae. Secondly, in the lowland plain of the Tihama between Bajil and the coast there are large stretches of sand dotted more or less uniformly with clumps of *bokar*-grass (*Panicum turgidum*), each growing out of a little mound of blown sand accumulated among its own stems, and rarely less than a yard apart.

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* Rathjens and von Wissmann, the authors cited above with reference to the geology, have in the same volume (figs. 21 and 56) indicated diagrammatically the zones of wild vegetation and cultivation from sea-level up to over 9,600 ft. They deal mainly with the old route from Hodeida up to San‘a *viâ* Manakha, a part of the country not visited by the writer and Mr. Britton, but the vegetational zones are, broadly speaking, the same.

This is almost the only plant over considerable areas, and forms what has been named the bokar-zone, just inland of the zone of *Suaeda* and other maritime plants.

The lecture on which this article is based included some references to wild mammals and reptiles, and many allusions to insects. The latter cannot yet be dealt with in detail, since the purpose of the article is only to indicate the natural-history background on which the main task of the Expedition was undertaken.

PROCEEDINGS OF THE GENERAL MEETING

27 April 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 13 April 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read :—For the first time, in favour of Kadabam Vedantasrinivas Srinath, Winifred Walker and Harold Walkden.

A certificate of recommendation of the following candidate for Associateship was read for the second time :—John Ardagh.

The President reported the death of Miss Florence Mary Rich, Fellow of the Society.

The President announced that a Hooker Lecture, on ‘ The relations of the flora and fauna of Ireland to those of other countries ’, would be given by Dr. R. Lloyd Praeger at the next General Meeting.

The President referred to the recent removal of the Linnaean Collections to Woburn Abbey, where H.G. The Duke of Bedford had made special preparations in the old indoor tennis court for their reception.

Miss **Dora Stafford** (Visitor) gave an account, illustrated with lantern-slides, ‘ On the Flora of Southern Peru ’. [Printed below.]

The **President**, in calling upon Dr. Skottsberg, said that it was not necessary for him to introduce the lecturer, nor to say how delighted they were when any Swedish biologist attended a meeting of the Linnean Society: he could assure Dr. Skottsberg that none was more welcome than he. They were to have a lecture on a subject about which it was valuable to have Dr. Skottsberg's latest views.

Prof. C. **Skottsberg** then gave his account, illustrated with coloured lantern-slides, ‘ Remarks on the Hawaiian Flora ’. [Printed in a shortened form, p. 181.]

The following paper was read in title :—

‘ Descriptions of two new species of fossil Chitons from Mornington, Victoria ’. By **Edwin Ashby**, F.L.S. [Printed below, p. 186.]

ON THE FLORA OF SOUTHERN PERU.

By Dora Stafford.

When I speak of southern Peru I am referring only to the departments of Arequipa, Cuzco, Puno and the north coast of Moquegua.

The country is divided climatically and botanically into rough sections. The Lomas, which is the name for the coast hills, run up to 3,000 feet and stretch inland for about fifteen miles. What is known as the normal climate is a season of mists from May to October and dry weather for the rest of the year. Further inland between the Tambo and Vitor rivers is a wide desert which gradually rises to the foot of the Andes where neither rain nor mist fall. From roughly 6,000 to 10,000 feet in the Arequipa district and on the three mountains, Chachini, El Misti and Pichu Pichu, the rain period is from January to March—above 10,000 feet the storms begin a month earlier and last usually into April. Beyond these peaks are the high plains from 12,000–15,000 feet above sea-level, where, as well as the season of snow and rain from December to April, there is a fortnight of heavy rain in October, which starts the spring flowering plants into growth. Above 15,000 feet in the Cordillera there may be snowstorms at any time throughout the dry season—usually there is a storm about once a month, almost certainly one at the beginning of August—as well as the period of rain. Between the high ranges are comparatively warm, sheltered valleys at 11,000 to 12,000 feet and the eastern slopes from 12,000 down to roughly 6,000 feet, where there is a wide belt between the high Andean flora and the beginning of the tropical flora where the rains start earlier and last longer.

On the coast it is difficult to say what a normal year is, as it depends on the length of time on which the average is taken. So many things may influence the climate—an earthquake in the bed of the sea near the coast throws cold water to the surface and causes mist to gather. In some years the birds and fish die in great numbers, and it is thought that the cold current from the south has moved nearer the land, or sharks are seen in the bay, which seems to suggest that a warm current from the north has set in. There are, too, freaks of weather, such as one tropical storm in 1938, which fell on the Lomas, when large baulks of timber and thousands of barrels which were being used in the building of the new port of Matarani were swept away by a torrent in the bed of which no one had ever seen even a trickle of water. At various times during the last twelve years I have seen the Lomas with scarcely a sign of vegetation in what should have been the season of mists—then seeds, bulbs, shrubs and the few stunted trees remain dormant—and at the same level at the same time of year I have had to push my way through vegetation breast high, and the hollows and dips of the hills have been a purple sea of *Palaua geranioides* and *Onoseris odorata* and blue drifts of *Lupinus mollendoensis*. So that there is still a fine field for the botanist who is fortunate enough to be there in a year of heavy mists.

It is quite clear from the extraordinary mixture of plant life that there must have been great changes from time to time.

The surface soil is sand and shell swept up by tidal waves, but where the hills have been split apart by volcanic action the subsoil is heavy clay. Buried in the sand as fossils are portions of tree trunks.

Cacti such as *Neoraimondia macrostibas* and species of *Cereus* are covered with a thick mat of lichen, an *Usnea*, out of which *Tillandsia latifolia* grows.

There are a certain number of ferns, amongst them *Polypodium mollendense*, which grows on lichen-covered branches of trees and on their roots. *Adiantum chilense* grows in nearly all districts up to 15,000 feet and *Cystopteris fragilis* in all districts up to 16,000 feet.

Nolanaceae are well represented from sea-level, where *Nolana thinophylla*, as the name suggests, forms mounds actually on the sea-shore, up to 3,000 feet on the edge of the desert plateau where *Nolana Guentheri* grows. *Nolana pilosa*, which is one of the commonest, is blue where it grows in sand in the Mollendo district; but near Ilo, fifty miles further south, it is deep violet and grows in the clefts of rock on the sea-shore. The rock in both Mollendo and Ilo is gneiss.

Ipomoea Plummerae and *Anthericum eccremorrhizum* are peculiar in that they grow in the Lomas at a few hundred feet above sea-level and also in the Arequipa district at 8,000 feet, where rainstorms are heavy and in June there is sharp nightly frost, and yet again in the valleys and hillsides of the Cuzco and Sicuani districts, where snowstorms are fairly frequent and frost severe at certain times of the year. There is no variation in the size of the plant or the size or colour of the flower under these very different conditions.

Calandrinia Ruizii again varies in colour. Above Mollendo it is magenta and in the Ilo district it is yellow. It grows on sand-covered ledges of rock in both cases.

Two of the potatoes that I found in this district were *Solanum tuberiferum* and *Solanum montanum*. And *Lycium fragosum*, a rather prostrate shrub, is found in the valleys.

Of the Amaryllidaceae *Cooperia albicans*, which has white flowers, grows in a mixture of sand and shell on the bare hillside above Mollendo, but near Ilo one finds it only in the dry beds where the watercourses are underground, with *Stenomesson incanum*, which has a red flower.

Pure white is an unusual colour for flowers in the south of Peru. They are nearly all shot or feathered with blue or red or have dark bases. Red is also unusual. In most flowers of this colour yellow appears to be the basic pigment, and red is only superimposed. *Salvia tubiflora* is, I think, one of the few exceptions.

There are a few shrubs such as *Frankenia peruviana*, *Mentzelia chilensis* and *Verbena clavata* or *fissa*.

Great tracts of the hills are covered with the orange sunflower, *Viguiera Weberbaueri*, but it apparently so robs the ground that where it grows nothing else will. *Oxalis carnosa* grows in the rocks, and the children of Mollendo peel and eat the corms of *Oxalis lomana*. They look and taste rather like cob-nuts.

The desert of La Joya, which gradually rises from 3,000 feet to the lower slopes of the Andes, is covered for the first few miles with tufts of the orange lichen, *Teloschistes flavicans*, and with *Tillandsia purpurea*. Both drift, apparently rootless, and where the ground slopes the surface is so loose that it seems as if one were walking in a swiftly moving river of lichen.

Above the Vitor valley the vegetation appears again in the hills which rise to the plain of Arequipa. Occasionally in years of abnormal rainfall in the mountains the clouds creep down to the lowest hills, but in normal seasons the vegetation depends on moisture seeping down below the surface from the snow above.

The climate of the Arequipa district is a season of rain during the months of January, February and March and clear sunny days until the "nevadas" (which means that snowstorms are gathering in the Sierra) bring cloudy skies in November and December. The wind rises every day at 11 a.m. and blows fairly strongly until sundown. In the month of August there are many earth tremors, exceptionally high winds and occasional sandstorms, and a very rapid and unaccountable rise and fall in temperature between 4 and 6 p.m. in the afternoon, which has a disastrous effect on cultivated vegetation. There are many miles of small holdings to the west of Arequipa, which are irrigated from the River Chile. They are spreading away from the direction of the rains, which come mainly from the east, and cultivation and irrigation has not had what I have always thought was the usual effect on the climate of attracting moisture. On the contrary, for the last three years there has been a drought, which was broken this year.

The soil is volcanic, and so rich that three crops of alfalfa can be harvested in a year. Indian corn is grown in great quantity and forms the staple diet of the Indians and the poorer cholos—that is, Peruvians with Indian blood.

On sandy pampas at the foot of the mountains there are large drifts of an Iridacea—*Mastigostyla cyrtophylla*. *Cacabus pusillus* trails everywhere and *Portulaca peruviana* and occasional plants of *Hoffmanseggia gracilis* grow amongst Cacti of the *Cereus* type. *Portulaca peruviana* also grows in the hills near Juliaca at 12,000 feet and in the Sicuani district at 11,000 feet. Near Arequipa the colour of the flower is magenta, in the Juliaca hills it grows wherever the sand has blown down from the high pampas and is rose or orange in colour, and in the Sicuani valley and the Cuzco hills it is found only in a yellow form growing in loam.

Higher up there is a carpet of species of *Opuntia*. I use the word carpet literally. The donkeys and llamas of the yareta and brushwood cutters kick off the joints of this small cactus, and they lie thickly over the sand, then root in the rainy season, and make walking a martyrdom. Wherever there is a rocky bank at 8,000 to 9,000 feet one finds a red-flowered species of *Borzicactus*.

On the slopes of the three mountains Chachani, El Misti and Pichu Pichu there is a belt of shrubs at 10,000–12,000 feet. *Balbisia Weberbaueri* covers much of the steep stony hillside. On flat ground a very dwarf shrub, *Verbena juniperina* var. *grisea*, grows; like other Peruvian Verbenas it is very sweetly scented. *Huthia coerulea*, *Mutisia viciifolia*, *Chuquiragua* and a species of *Dunalia* and *Lycianthes lycioides* are found on banks of watercourses.

Lycianthes lycioides has one peculiarity. Above Arequipa the flowers are of a brilliant blue, but the higher one goes the paler it becomes, until at 12,000 feet in the Sicuani valley it is almost white and only faintly washed with blue. This struck me as unusual.

In La Paz, in Bolivia, the flowers of *Mutisia viciifolia* var. *Candolleana* are greatly prized and are sold in the market at ten centavos a flower. They are boiled, and the essence is used as a remedy for heart trouble.

Prescott, in the ' Conquest of Peru ', made the extraordinary statement that Pizarro ordered galleys to be built in Arequipa. The nearest suitable wood for such a purpose would have been at least a month's journey away. All the trees in the Arequipa district have been introduced either from other parts of Peru or from other countries.

From Chachani comes the fuel which is used in the town and surrounding villages. The poorer classes use the brushwood from the shrubs, and the first time that I saw *Balbisia Weberbaueri* it was piled on the back of a donkey, being hawked round the poor quarter of Arequipa. The flower is a clear yellow in colour, which is unusual; for nearly all yellow flowers one comes across are flushed or streaked with red.

About 12,000–14,000 feet grows a species of *Polylepis* which is used to light the stoves of the upper classes. At 15,000 feet and over one finds *Azorella yareta*, one of the Umbelliferae, which contains a resin-like creosote and is burnt on the farms with cow- and llama-dung. There are three varieties. It grows in huge cushions, and is cut and left to dry on the hillside during the winter.

On El Misti there are acres of a species of *Lupinus*, and the other most noticeable plants on the three mountains at this height are *Chabraea laciniata*, *Senecio culcitioides*, *Bomarea curvipes*, Calceolarias such as *C. Fiebrigiana* and a very dwarf species of *Cajophora* which grows under the rocks, and another rather like *C. Pentlandii*.

Above the grass line one finds the Nototriches, on Chachani *N. biflora*, on El Misti *N. turritella* and on Pichu Pichu a new species.

To the west of Chachani one comes to sandy hilly country which gradually climbs to the Pampa de Arrieros. Yura is a primitive spa where the strong sulphur waters are said to alleviate or cure many diseases. Here one finds *Stenomesson humile* at its best. The bulbs, which are the size of my clenched fist, are encased in many coverings. In the Titicaca and Cuzco districts, where it also grows, the bulbs are long and thin like my little finger, and are without any protective covering, although the frost there is much more severe.

The flowers do not vary in size in proportion. Apparently frost will penetrate easily through sand.

Further inland to the east are half sandy, half grassy, well-watered pampas such as Crucero Alto, the highest point of the Arequipa–Puno line at 14,666 feet. One gets the first sight of Andean meadows with Gentians, Nototriches, Perezias and many creeping Compositae.

In the same district to the south-east lies San Antonio de Esquilache, an old Spanish silver-mine. This part of the country was far better known in the seventeenth century than it is to-day. The mine was discovered by Duran, a partner of the famous miner, Salcedo, about the year 1603. It was rapidly developed, and given the name of the Viceroy who governed the country at the time. A mint was established there, and a High Court of Justice and other institutions were granted, and the town increased until it contained 3,000 inhabitants solely dependent on the mine. Now a few huts and a large church are all that remain. The church has a window that is made of alabaster. The camp is 15,000 feet up, in the centre of the crater of a volcano the walls of which run up to 17,000 feet. The rock is andesite and the soil alkaline. The mine is worked for lead, gold and silver, and where the minerals are poor the flora is rich. On one bare stony slope it seemed as if all the plants of the neighbourhood were gathered together, amongst them *Nototriche pedicularifolia* and two new species. These two new species must, I feel, at some time have been sought after by man, bird or beast, because they are so camouflaged by nature. In the case of one the leaves imitate so closely the soil in which they grow that it is almost impossible from a short distance to see where the plant leaves off and the earth begins. To find the other one has to go down on one's hands and knees and search the ground where it is likely to grow. I only came upon it by chance because I happened to sit down and put my hand on the ground and found it was covered with little soft cushions. I had ridden that way before without noticing it. The other new species that I found make no attempt to conceal themselves. Nor does *Werneria sedoides*, which can be seen from a great distance. It is apparently a water-loving plant, as it always grows where small glaciers have formed or in the beds of shallow streams.

Werneria ciliolata and another *Werneria* near *W. carnosula*, both creeping yellow-flowered beside the rocks, and the white or violet-flushed *Werneria digitata* provide food for the vicunas.

For some years the shooting and export of skins of vicunas has been forbidden, although it is possible to obtain a government permit for a few days' sport limited to a certain number of head. But prohibition does not seem as if it will have the effect that was intended of preserving them. The male vicunas herd together in odd numbers—threes, fives, sevens and so on—in these days one can sometimes see as many as seventeen in one herd. The Indians cannot shoot the males, as they move so swiftly (in any case few have guns), but they follow the females who can only travel slowly with their young, and trap them, so that in the last few years the number of males has increased very much and the females are dying out, and in time they will be as scarce as they were before prohibition.

The leaves of *Werneria Mandoniana* are sold in the Puno market for medicinal purposes.

There are also in this district a very large number of Perezias, in shades of scarlet, brown, blue, purple, rose and white. They are extremely difficult to identify, and colour and the time of year of flowering seems to play an important part in their classification. *Perezia pinnatifida* is much used by the Indians as a remedy in cases of kidney disease. It is one of those plants the flowers of which vary in colour between red and yellow according to the locality.

It was somewhat surprising to find so many Cacti, and there were large mounds of a species of *Opuntia* at well over 15,000 feet. It will always amaze me to see Cacti flowering in the snow, as they do if there happens to be a snowstorm at any time between August and October in these parts.

From Pichacani (a derelict mining village below San Antonio) to Lake Titicaca is undulating grassland about 13,000 feet above sea-level. Near Puno, in October, it is covered with *Haylockia andina*, a small Zephyranthus. In March and April in the same country one finds Violas, Oxalis, Geraniums, Malvas, Calceolarias, Lupins, and a small Iridacea, *Nemastylis brevicaulis*. *Viola pusillima*, *V. pygmaea*, *Malvastrum nubigena* and *M. Bakerianum* grow in the turf, the species of *Calceolaria* and *Lupinus* in the rocks. On the pampa round the lake *Bidens triplinervia* grows. The Indians extract a dye from the flowers for colouring their homespun clothes. At one time only local vegetable dyes were used, but now German dyes are imported in great quantity.

Further north between Lake Titicaca and Lake Uyumayo is a strip of moorland which is rich in Cacti of the Lobivia and Opuntia type. On rocky ridges you find *Verbena microphylla*. The rock is andesite except here and there, where there is an intrusion of granite.

From Juliaca a narrow plain runs between low hills on one side and the lower part of the Vilcanota range on the other until it widens out into a pampa which is blocked by the Cordillera de Carabaya. *Malvastrum Bakerianum*, *Liabum* *ovatum* and *L. bullatum* and *Gentiana sandiensis* grow in the shelter of stiff clumps of grass. Where the soil is sandy there are large clumps of *Opuntia campestris*. Of the medicinal plants in this part *Gomphrena acaulis* is the most popular with the Indians as a heart tonic.

My brother went on a tour of inspection of alpaca farms spread over the pampa, and took me with him. I noticed that round every farm *Buddleia arborea* was planted for protection. It is the one tree of many that have been tried that will live through the severe conditions in its early stages of growth. The conditions are prolonged drought and biting winds and frost almost nightly throughout the year. There is seldom less than 2° F., and in June, July and August there may be 28°.

In the Vilcanota range I stayed at an alpaca farm about 14,000 feet up on the slopes of Cunurana. In May, June and July, when the flowers are at their best, the hillsides are covered with sheets of ice until the sun has sufficient power to melt them, and one has to be down again by five o'clock when it starts to freeze again. This makes the working hours very short.

Capethia integrifolia is one of the earliest spring flowers.

Where you get the same type of country and the same conditions you will find the same genera but different species ; but in each genus there seems to be one species that will wander from its own locality and grow under various conditions. Amongst the Nototriches it is *N. longirostris*, amongst the Geraniums it is *G. sessiliflorum*, and amongst the Wernerias it is *W. nubigena*, and so on. In some cases, too, you will find a sheltered valley on one of the high plains, and you will then get a small group of plants from a warm valley perhaps 200 miles away.

I am frequently asked at what height is the snow-line in Peru. In the mountains that I know and have climbed there does not appear to be a snow-line, but an ice-line. Where there are glaciers the snow quickly turns to ice as it falls; where there are no glaciers it melts away Below the glaciers there are sometimes ice-fields, but the ice-line depends on how far the glacier has travelled, and the height therefore varies. Even at 16,000 and 17,000 feet the plants are not covered by snow except for a few days at a time unless the storms are unusually heavy and prolonged.

Part of the Vilcanota range is a barrier between the bleak uplands and the comparatively warm valley of Sicuani which winds finally along a narrow gorge to Cuzco. Here one comes again into the region of shrubs, *Lycianthes lycioides*, *Barnadesia horrida* and the brilliant blue-flowered *Salvia sarmentosa*, which I found in 1934. The river, which rises in the Vilcanota range, is one of the tributaries of the Amazon. It is fed from lakes in hollowed hilltops on either side. One is used to seeing small lakes in the craters of small volcanoes, but just in this part the lakes are sometimes several miles across.

Cacti, such as *Trichocereus cuzcoensis*, are used as hedges, through which *Passiflora gracilens* trails, to fields of Indian corn and wheat, and in October *Pyrolirion aurantiacum* begin to push up.

Ismene calathina, which grows in the hills above Pisac, is brought down into the Urubamba valley and cultivated by the Indians for sale in the local markets.

In the hills round Cuzco one comes to the beginning of the belt which runs down to the tropical flora. On the ridges one still finds *Malvastrum Bakerianum* var. *strigosum* and Gentians such as *G. exacoides* and *G. prostrata*; but on the slopes and in valleys one comes across Cypellas such as *C. Herrerae*, *Bomarea ovata*, *B. involucrosa* and large and handsome Stenomessons such as *S. variegatum* and *S. coccineum*.

I paid three short visits to Machu Picchu, which lies to the north of Cuzco, so short that I do not feel that I know enough about this part to speak of it. It seemed an extraordinary mixture to me. The most interesting plants were *Epidendrum cuzcoense*, which grew in the hillsides, in the tops of trees, in the roofs of the few wooden shanties that comprised the village, and in rocks of silurian slate, also a species of *Lupinus* which was of the most unusual shade of blue, an *Orchis* which looked as if it had strayed from an English meadow, and *Anemone helleborifolia* which would have looked more at home in the Swiss Alps. The ferns were very fine, and had names suggestive of international expeditions—*Pityrogramma austro-americana* and *Selaginella novae-hollandiae*. This was the nearest point to the tropical region that I reached.

I then went down by the new road to Marcapata. The outstanding plants from my point of view were *Ourisia chamaedryfolia* var. *elegans* and a fern with apparently endless growth to the fronds, *Jamesonia scalaris*. The latter had only just started into growth and was already two feet long.

Further back I crossed the Aricoma Pass and went down to Limbani. Here again the most interesting plant to me was what may be a new species of *Ourisia*, but it has not yet been identified.

The PRESIDENT, in thanking Miss Stafford for her lecture, said it was obvious how advantageous it was when making a botanical collection to have an intimate knowledge of a country and of its inhabitants. Doubtless all present had noticed the numerous tit-bits of information about the uses of plants. In view of the recent expedition to Lake Titicaca it was particularly interesting to get an idea of the vegetation of neighbouring regions.

REMARKS ON THE HAWAIIAN FLORA.

By Prof. C. Skottsberg.

Nowhere is the Polynesian flora more varied or more specialized than in the Hawaiian islands. These islands are entirely volcanic and regarded by the majority of geologists as Oceanic from their beginning. They are, for their size, richer in genera and species than many continental areas, and in its constitution the flora is no more Oceanic than that of Fiji, which dates back to the Melanesian continental extension, or of New Zealand or New Caledonia, which from a geological standpoint are continents.

The current idea is that Hawaii received its vegetation through overseas migration from all sides. The distances are large, ±2,000 miles to America, 4–5,000 to Asia, 3–4,000 to Australia and New Zealand. As endemism is very high, perhaps close to 90 per cent. of the species and 20 per cent. of the genera of phanerogams being endemic, many of which altogether lack near relatives, the conclusion is either that such relatives have all disappeared or changed, or that everything on its arrival in Hawaii gave rise to something new; all this should have happened within recent times, because the rocks are of neovolcanic type. It is true that there are very recent rocks because there are still active volcanoes, but this does not prove that the islands are young—in any case, the flora is very old. It is no insular mixture of haphazard immigrants. Many genera are large and strongly differentiated into subgenera or sections and consist of local segregates and various life-forms adapted to different kinds of stations. Everything points towards the same course of events as in the continental floras.

Whichever of the two eventualities we prefer, if islands are oceanic *ab initio*, their flora or its ancestors must have been able to travel across the ocean. If this had been true everywhere—and I can see no reason why not—the plant world of the globe should have a different distribution than it actually has. The fact that so many species in the Hawaiian group—and in other island groups or anywhere where there are barriers—have a very restricted range does not seem to speak in favour of a great power to migrate. Currents are, of course, responsible for the wide distribution of a number of tropical shore species with buoyant diaspores, and such species are present also in Hawaii. The winds are known to carry light units over great distances, and it is supposed that this is the reason why many cryptogams are widely scattered. Of the birds we can leave out the marine species, exactly those which cover enormous distances, as they do not go into the forest to eat drupes or berries, and the native stationary Hawaiian birds are just as peculiar as the phanerogams. They help to disseminate seeds within the archipelago, but not beyond. We must not forget that several migratory birds are regular visitors in the mountains of Hawaii, and the presence there of some widespread species is probably due to these visits. With this exception, nothing seems to have been brought to Hawaii for ages. The objection that many species arrive without being able to get a foothold lies near to hand. I do not deny this possibility, but certainly the natural agencies ought to have brought *something* in recent times that met with success. The extraordinary endemism shows that this did not happen. The idea that biotic factors are responsible for the failure is contradicted by the fact that as soon as a *new* dispersal agency, man, came into effect, plants not only arrived from all quarters but also got a foothold, in many cases in the natural vegetation, especially where this is open.

From this we can only conclude that the natural agencies were effective only during past epochs. This is precisely the result to which Mr. H. B. Guppy arrived in his admirable discussion of the origin of the Hawaiian flora. Unfortunately such an assumption rests on no foundation at all.

Let us disregard for a while the peculiar endemic character of the flora. If it arrived by overseas migration, the main source should have been America which is less distant, especially as winds and currents come from that direction. The analysis shows that this is not the case; the flora points West and South.

The islands lie in the tropical belt, and the lowland plants show a tropical or subtropical character, whereas higher up temperate types can be expected. The islands rise over 13,000 ft. I shall deal with the Megathermics first. Among them are a number of endemic genera which, from their actual distribution, are what I used to call Eupacific. I think we can get a little further if we break up this element and divide the genera among the various other groups, according to the affinity they show.

Of the little over 200 genera found in Hawaii, eighteen are large Pantropical; and the affinity of the Hawaiian species, all endemic, has not been sufficiently investigated. Four endemic genera point both East and West. In many cases he Hawaiian species of a non-endemic genus are very strongly marked, for instance, the cushion species of *Panicum* in the mountain bogs. Other remarkable types are the ligneous *Euphorbiae* which, as well as *Smilax* and *Bidens*, form their own section. *Hibiscus* includes a number of remarkable species. Among the striking endemic genera are *Kokia* and *Hibiscadelphus*, relatives of *Gossypium*. A very interesting case is furnished by the Hawaiian Begonia, *Hillebrandia sandwicensis*, supposed to represent a very ancient type in the Begoniaceae.

The remaining Tropical genera point either West or East. Fifteen are PALEOTROPICAL, and of these, five are endemic with Old World relations; the Labiaceous *Haplostachys*, *Phyllostegia*, and *Stenogyne* are peculiar because their closest relative is the Mediterranean shrub *Prasium*. Other Paleotropic genera are *Embelia*, *Rhus*, *Dracaena*, probably also the endemic *Charpentiera*, the only Amarantaceous tree.

One of the largest groups—forty-nine genera, six of these endemic—forms a branch of the MALESIAN flora which has ts main centre in SE. Asia and extends to Australia and New Zealand. Some examples are *Isachne*, *Pipturus*, *Cocculus*, *Erythrina*, *Strongylodon*, *Canavalia*, *Wikstroemia*, *Ceodes*, *Sapindus*, *Phyllanthus*, *Diospyros*, *Planchonella*, *Ilex* (with a special Pacific section), *Plectronia*, *Psychotria*, and the endemic Rubiaceous genera. An important Polynesian type s *Cyrtandra* with one of its main centres in Hawaii.

The TROPICAL BEACH plants, which may have reached Hawaii from the West or South-west by a detour, are represented by twelve genera. No species is endemic. Typical members of this group are *Ipomoea Pes-caprae* and *Scaevola rutescens*. *Cassytha filiformis* is conveniently annexed to this group. The Paleotropical, Malesian, and wide spread group ogether make up 55 per cent. of all genera.

The NEOTROPICAL group is quite small in comparison, omprising only thirteen genera. The species may be endemic but are seldom strongly marked, standing close to American pecies ; this is true of *Gossypium*, *Cleome*, *Abutilon*, *Lycium*, *Sisyrinchium*, etc. *Remya* is an endemic Composite genus f American parentage and the same may be true of the nearly ndemic *Lipochaeta*.

The largest element, fifty-seven genera, points to a southern rigin and is called AUSTRAL. It includes twenty-one endemic, Eupacific genera. The remaining are mainly or exclusively t home in the Southern Hemisphere and their distribution makes us look for their ancestral home in the far south. Many elong to the flora of Australia, New Guinea, New Caledonia, nd New Zealand ; in many cases they reach Malaya and may be fairly well represented there, some also on Madagascar or the Mascarene islands, few in South America, where there are other endemic genera probably belonging to this Austra assemblage. Examples are offered in *Joinvillea*, *Dianella*, *Cordyline*, *Pandanaceae*, *Gahnia*, *Urticaceae*, *Santalum*, the phyllodine *Acaciae*, Araliaceae, *Metrosideros*, *Styphelia*, *Myoporum*, *Coprosma*, *Scaevola*, *Pittosporum*, and many more.

The endemic Austral genera occupy as a rule an independent position ; only *Cheirodendron* and *Camphusia* may be said to show very obvious Austral affinities. Of great interest are the Lobeliaceae and Compositae. The former are represented in Hawaii by seven genera, six endemic ones beside *Lobelia* which appears in two distinct types ; one of these seems near the Indo-Malayan species, but according to my belief this is because they have the same source. Hardly less peculiar are the Compositae, the much renowned silversword (*Argyroxiphium*), *Wilkesia*, *Raillardia*, *Dubautia*, etc. all important components of the montane and alpine vegetation. In some cases distant Austral affinities have been found and no other. *Tetramolopium* is common to New Guinea and Hawaii.

Physiologically, the Austral element is *not* tropical, but temperate to subtropical. Ultimately it is derived from Antarctica, forming fragments of its Cretaceous and Tertiary floras which are scattered all around the world and include numerous genera or even families not represented in Hawaii such as the Protaceae for instance. All these now live far removed from their ancestral home. Nearer to this, in the Subantarctic zone, we encounter the hardier types known as ANTARCTIC or OLD ANTARCTIC. They are most important in Fuegia and in the subantarctic islands ; they are strongly represented in New Zealand, Tasmania, and east Australia ; and they reach Malaya over New Guinea. Single endemic species are found in Africa and the Mascarene islands. In South America they advance far north along the Andes; in Polynesia they reach Hawaii, where there are ten genera (or, in cases, sections of large, world-wide genera), belonging to eight families. It is significant that practically all species, but no genus, is endemic. Several are leading genera in the mountain bog flora (*Oreobolus*, *Astelia*, *Acaena*, *Lagenophora*). The Hawaiian *Gunnerae* are of particular interest as having nothing to do with any other group in the genus than the *chilensis*-group.

Finally, we have a group likely to rouse a great deal of interest and to give rise to complicated problems. I have called it BOREAL for want of a better name. The genera are at least in our time, north temperate or montane-alpine in lower latitudes. Such genera are *Rumex*, *Silene*, *Viola*, *Rubus*, *Vicia*, *Geranium*, *Sanicula*, *Vaccinium*, *Lysimachia*

Artemisia, etc., to which, with much hesitation, I add *Schiedea* and *Alsinidendron* (this sometimes included under *Schiedea*) :—together they number twenty-two. With few exceptions they are frutescent or dwarf arboreous, even if all their congeners in other parts of the world are herbaceous (as in *Geranium*, *Lysimachia*, and—almost—in *Viola*). It is evident that these Boreal genera are no late arrivals in Hawaii, but have a very long history behind them.

Lastly, nine non-endemic water- and marsh-plants, such as *Potamogeton*, *Najas*, *Polygonum*, *Drosera*, may have arrived with migratory birds from Canada, Alaska, or perhaps Siberia. Some Cyperaceous species probably came from the same source.

With regard to the polyphyletic composition of the Hawaiian flora we can come to no other conclusion than that it had a long and complicated history. Possibly the Austral element is the oldest. It is not likely that this flora has become evolved in the islands, such as we see them, from germs brought from all directions by agencies of which we know nothing. It is more probable that its history dates back to times when overland migration was possible.

It is easy to imagine a North-east—East extension of Malesia to a line roughly indicated by the Bonin, Hawaiian, Marquesas, and Juan Fernandez islands, a continental extension which eventually explains the presence of all the various floral elements. There are good signs that this line indicates an old route of migration. This land mass would have become submerged through a series of faults in connection with the formation of volcanic chains, beginning NE. and proceeding SW. ; thus, Hawaii and Marquesas would be among the more ancient. From a geographical standpoint a land extension of such magnitude requires compensation in other regions, as we cannot simply encroach upon the Pacific basin without providing for its waters in some way or other ; it also involves very considerable vertical movements in the earth's crust. For these reasons many biologists have recurred to Wegener's theory of horizontal displacements of the continental blocks. In order to account for Polynesia, the garland theory must be applied, but the difficulties are many and assumption is piled upon assumption. The most urgent task is, perhaps, not to speculate until new facts have come to light, and, to begin with, to investigate the affinities of every single animal and plant species, allowing us to arrive at tolerably safe conclusions with regard to centres of evolution and routes of migration.

One thing is certain. However Hawaii and the other island chains originated, they have remained biologically isolated until man broke the isolation, first the Polynesian, who intentionally carried with him his useful plants from island to island,

and later on other races, who did the same on a much large scale, and, in addition, unintentionally started an immigratio into Polynesia of hundreds of species, all undesirable alien and many of them dangerous. Thereby the original aspec of the flora and fauna is constantly changing. We are told by malacologists that the original Pacific land snail fauna is very ancient and lacks all later Tertiary features. Th insular world is characterized not only by what it contains but also by what it lacks. Mammals, reptiles, and fres water fishes are absent. No conifers cross the Melanesia border. The Hawaiian islands possess almost nothing of th enormously rich Malesian orchid flora. Large, otherwis dominating families, like the Liliaceae, Rosaceae, Leguminosae Umbelliferae, and Compositae, are very weakly represented Hawaii is behind time, conservative, unmodern. Most o the great revolutions connected with the building-up of th Tertiary mountain chain system appear to have passe unnoticed by this ancient insular world.

Discussion.—

Dr. J. C. Willis expressed full agreement with Dr. Skottsberg's views on the origin of the flora of the Hawaiian islands.

Professor R. R. Gates said that the problem of the endemic flora of Hawaii in relation to the whole Pacific region had been so interestingly presented by Professor Skottsberg that thei minds were bristling with questions. He would like to ask whether any hydrographic observations had been made which would indicate whether the present islands were a remnant of a larger land mass, and whether there was any geologica evidence of sedimentary rocks of an earlier date than th relatively recent lavas.

Dr. Skottsberg replied that the islands are entirely volcanic.

FOSSIL CHITONS FROM MORNINGTON, VICTORIA.

By Edwin Ashby, F.L.S.

[Plate 8.]

The specimens described were obtained from the Balcombian beds of Mornington, Victoria, by Mr. F. A. Cudmore of Melbourne, to whom I am indebted for the *Acanthochiton*. The other specimens were included in material from the same source which had been sent to Dr. J. Sulc of Prague.

Ocellochiton, subgen. nov.

A subgenus of *Callochiton* with longitudinal ribs in the pleural areas, characterized by the presence at the posterior end of each rib at its junction with the lateral area of an aperture, approximately equal in diameter to the width of the rib, presumably associated with a sense-organ of the type called 'eye' or 'ocellus'. The occurrence of these organs suggests a possible affinity with *Lorica*.

CALLOCHITON (OCELLOCHITON) SULCI, sp. nov. (Pl. 3, figs. 1–3.)

The *head-valve* is flattish, but with the apex elevated, and is evenly decorated with minute crowded pearl-like circular grains; there is a single semicircular groove near the outer margin. The insertion plate is short and thick, with twenty-one blunt teeth. The eaves are thick and spongy, overhanging a little more than in the other valves. At the apex the tegmentum is narrowly folded over, forming a comb-like process under the hood, an unusual feature.

In the *median valves* the dorsal area is smooth; the pleural area very broad, smooth except for the six narrow widely spaced longitudinal ribs, of which the two innermost are nearer together and shorter while the other four are equidistant and extend across the area; at their junctions with the lateral area there are five apertures (three only fully developed) equal in diameter to the width of the ribs; the outermost hole shows the enamel-like coating of the tegmentum continuing down the interior of the aperture. The lateral area is narrow in comparison with the pleural area, is raised and decorated with irregularly placed small circular grains; there are several shallow concentric growth furrows, the outer one well defined and deep. The sutural laminae are well developed but shallow, with a very broad sinus and curved anterior edge. Under the eaves the articulamentum is very thick and spongy; the insertion plate stops short of the posterior edge of the valve, but the spongy eaves continue to the margin. Slits 1/1.

In the *tail-valve* the mucro is not raised; the anterior part is similar to the pleural areas in the median valves except that the longitudinal ribs are more beaded or subgranulose; the area behind the mucro is about three-quarters of the whole valve, at first steep and then flat and slightly concave, decorated with circular grains similar to those in the lateral areas of the median valves. The insertion plate of the tail-valve is divided into nineteen teeth, all blunt, thick, short and cut to a spongy base; a large number of these are quasi-double. The spongy shell above the insertion plate is very thick and the tegmentum barely overhangs this. The sutural laminae are shallow and the sutural sinus very broad.

Measurements in mm.: head-valve 1×2; median valve $2 \times 3{\cdot}6$; tail-valve, $1{\cdot}8 \times 2$.

Holotype (median valve) with head- and tail-valves described above deposited in the South Australian Museum; a paratype (fragment of head-valve, median valve and tail-valve with 25-30 teeth) in the British Museum; a paratype (median valve with ? 3 ocelli on each side and fragment of tail-valve) in Sulc collection; a paratype (median valve with 3 or ? more ocelli, having margin of lateral area turned up and fragment of tail-valve) in the National Museum of Victoria; a paratype (median valve showing two slits and part of a third and fragment of tail-valve) in the National Museum, Washington.

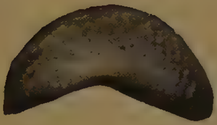
ACANTHOCHITON BALCOMBIENSIS, sp. nov. (Pl. 3, fig. 4.)

This species is based on a single valve from the Balcombian of Mornington, presented to the South Australian Museum by Mr. Cudmore.

Median valve.—Strongly carinated. The dorsal area is narrowly wedge-shaped, the central portion smooth except for growth-lines, the sides longitudinally grooved, the more lateral grooves being broken; the anterior third of this area is curved downwards, especially at the overhanging edge. The pleural area has eleven rows of flattish raised spaced grains, elliptical and almost flat near the dorsal area but gradually becoming more circular and raised towards the girdle; in the longest row I counted seventeen grains. Under a low power the grains appear crowded, but under a higher power (×20) they are distinctly spaced. There is a strongly raised diagonal rib, surmounted by a few large pear-shaped grains; between this rib and the posterior margin the grains are irregular and larger than in the pleural areas. The sutural laminae are broad, but shallow anteriorly; the sinus is broad and overhung by the tegmentum. Slits 1/1. On the inside there is no distinct groove but only a shallow groove from the slits. Angle of divergence 90°. Colour brown. Measurement 6×6 mm.

PROTOCHITON GRANULOSUS (Ashby and Torr).

Among the specimens sent by Dr. Sulc is a juvenile example of the tail-valve of this species. The granular sculpture, which appears to be solid, is on careful examination found to be hollow, as in the adult, in which the tail-valve was 7 mm. long by 7·5 mm. across; this valve measures 2×2·5 mm. The adult examples are greyish (perhaps stained); this valve is porcelain-white. In both the posterior area extends forward up the sides, but in the juvenile the grains are spherical while in the adult a great many are elliptical especially at the side; in both the dorsal area is broadly wedge-shaped and composed of granular riblets, but in the adult these riblets are more widely spaced; the portion corresponding with the pleural area in other chitons is very small and the grains elliptical, but more widely spaced in the adult.



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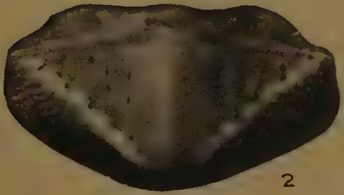

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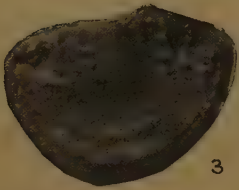

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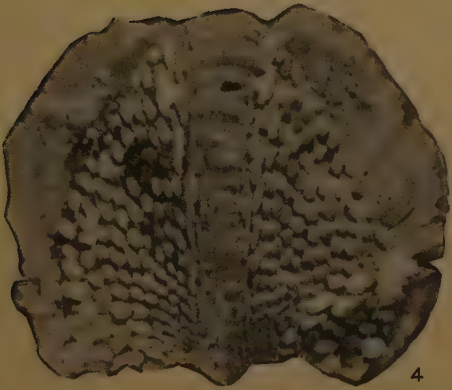

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FOSSIL CHITONS FROM AUSTRALIA.

EXPLANATION OF PLATE 3.

Fig. 1. *Callochiton* (*Ocellochiton*) *sulci*, head-valve, × 13.
Fig. 2. *Callochiton* (*Ocellochiton*) *sulci*, median valve, holotype, × 13.
Fig. 3. *Callochiton* (*Ocellochiton*) *sulci*, tail-valve, × 13.
Fig. 4. *Acanthochiton balcombiensis*, median valve, holotype, × 9·5.

Photographs from specimens in the Ashby collection, South Australian Museum, reg. nos. 13367 and 13366.

PROCEEDINGS OF THE GENERAL MEETING

11 May 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 27 April 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Alice Mary Geldart and Henry Alexander Lindeman.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Kadabam Vedantasrinivas Srinath, Winifred Walker, and Harold Walkden ; for the first time, in favour of John Walter Guerrier Lund.

The following candidate, whose name was read for the third time, was balloted for and elected a Fellow :—Ivan Robert Dale, M.A.

The following candidates, whose names were read for the third time, were balloted for and elected Foreign Members :—Prof. Alfred Ernst, Prof. William Albert Setchell, Prof. Alfred Rehder, Prof. Dr. Willem Marius Docters van Leeuwen, and Dr. William King Gregory.

The following candidate, whose name was read for the third time, was balloted for and elected an Associate :—John Ardagh.

Dr. Malcolm A. Smith, F.L.S., gave an account, illustrated with lantern-slides, of 'Evolutionary changes in the eye coverings of certain Lizards'.

Abstract.—

Two distinct types of changes can be followed; they are not connected in any way with one another. One is the development of the eyelids in the Geckos (Family Geckonidae), the other the formation of a fixed transparent covering to the eye in the Scinks (Family Scincidae). Different stages in development have been reached in different species and genera, but by taking the family as a whole an orthogenetic series can be arranged showing every stage in the process.

Most of the Geckos have a primitive form of eye covering. There are no eyelids, but the eye is covered with a fixed transparent disk beneath which it moves. It is the type of eye covering which is to be found in the fishes. In the genera *Gymnodactylus*, *Hemidactylus* and many others the eyelid is represented by a projecting fringe of tissue above and in front of the eyeball; there are no muscular fibres in it, and movement is not possible. In some species the fringe is more prominent than in others, e.g. in *Gymnodactylus intermedius* it projects 2 mm. from the orbit. A later stage in development can be seen in *Perochylus* and *Phelsuma*, in which the fringe completely encircles the eye. By the gradual lengthening of the fringe and the growth of muscle into it, as in *Eublepharis* and *Coleonyx*, the eyelids are formed, the conversion into an upper and lower lid being achieved by a lateral folding of the two halves of the circle. The African *Ptenopus* represents a stage intermediate between *Phelsuma* and *Eublepharis*, in that muscular fibres have developed and some movement is possible. Complete closure, however, cannot be made, and the transparent disk covering the eye remains. In the Eublepharids the disk has disappeared, its function as a covering of the eye being now undertaken by the eyelids. The method by which it disappears is not known.

In the family Scincidae the process is reversed, a fixed covering being formed by the appearance of a transparent disk in the lower eyelid, then the gradual growth of the disk and the lid, and finally its fixation by the union of the lower lid with the upper. The different stages can be followed in many genera, in particular *Leiolepisma*, *Riopa* and *Mabuya*; it culminates in *Ablepharus*, in which genus the process is complete or nearly so. A similar type of eye covering is to be found in the snakes, but whether they have acquired it by the same means is not known. The reason for this apparently retrogressive change in the Scinks is not evident. It is happening in species that live all over the world, and under all sorts of conditions of climate and surroundings, and in no way can it be regarded as an adaptation to environment. The acquisition of snake-like characters by the lizards, however, is already well known, and the changes in the eye covering must be numbered amongst them.

Discussion.—

Dr. H. A. Baylis asked whether the Scinks referred to by Dr. Smith were burrowers—in sand, for example—and whether the development of permanent eye coverings might be a protective device.

Dr. G. P. Bidder, Dr. G. R. de Beer and Mr. M. A. C. Hinton also spoke.

In reply to Dr. Baylis, Dr. Smith said that none of the Scinks to which he referred were burrowing forms. All of them lived an active life above ground, the genus in which the change had advanced farthest, namely *Ablepharus*, lived mainly in the trees.

After some introductory remarks by the President, Dr. R. Lloyd Praeger delivered the Hooker Lecture, on 'The relations of the flora and fauna of Ireland to those of other countries'. [Printed in full below, p. 192.]

The following papers were read in title :—

'Review of the South Australian representatives of the genus *Correa*, with descriptions of three new species.' By Edwin Ashby, F.L.S. [Printed below, p. 214.]

'Percy Sladen Expedition to Lake Titicaca, 1937. Scientific Reports :—

I. Introduction. By H. C. Gilson, M.A.

II. Meteorology. By H. C. Gilson, M.A., and P. F. Holmes, M.A.

III. The geology and physiography of the Altiplano of Peru and Bolivia. By H. P. Moon.

IV. Tardigrada. By Prof. Dr. Ernst Marcus.

V. Rotifères et Turbellariès. Par Prof. P. de Beauchamp.

VI. Oligochaeta. By Dr. L. Černosvitov.

VII. Sponges. By Dr. M. Burton.'

(Communicated by Prof. J. Stanley Gardiner, M.A., F.R.S., F.L.S.)

The President announced that his Presidential Address, to be given at the Anniversary Meeting on Wednesday, 24 May 1939, will deal with 'The expanding knowledge of Mycology since Linnaeus'.

THE HOOKER LECTURE

THE RELATIONS OF THE FLORA AND FAUNA OF IRELAND TO THOSE OF OTHER COUNTRIES.

By R. Lloyd Praeger, D.Sc.

In the first place, I wish to thank the Council of the Linnean Society for the honour they have done me in inviting me to deliver this year the Hooker Lecture; I am glad of the opportunity which this affords of laying my own trivial floral tribute at the feet of the great botanist whom this lectureship commemorates. The Council has rendered me a further service in selecting as my theme the only subject on which I may freely venture to speak in this room, redolent with memories of so many men of European reputation; for the study of the Irish flora and its relationships, and also of the fauna, has been to me one of lifelong interest.

The problem of Ireland, from the biological standpoint, is one that makes an appeal much wider than to the few naturalists who happen to live in that delectable country. As the most western land of the great Eurasian continent Ireland possesses a peculiar interest. As an island lying west of another island itself west of the European coast that interest is enhanced, and added importance attaches both as to what species are present in the country and what are absent from it.

Ireland, like Britain, is essentially a portion of the European land-mass. Both islands stand on a shelf almost as high as the land which constitutes western Europe, and covered with a mere film of water as compared with the oceanic depths prevailing to the west. Were geographical and climatic conditions stable, questions connected with the British and Irish flora and fauna would be comparatively simple. They would be merely those which might arise from long-continued migration from the land-mass lying to the east and south-east, as modified by the increasing influence of the Atlantic Ocean as fauna and flora moved westward. That influence is marked, for the eastern Atlantic is the warmest sea to be found in the world in equally high latitudes. Among other results it may have had a deterrent effect on the forward western march of immigrants which preferred continental rather than Atlantic conditions. That term Atlantic, as used in this connection, is mostly a relative one. To the naturalist in Dublin it connotes the conditions of flora or fauna prevailing in Kerry and Connemara and Donegal. In London I presume it would be used as embracing the whole of Ireland and the western side of Britain—though H. C. Watson (1847), in his desire to establish northern and southern as well as eastern and western botanical regions, limited its application to western England. The continental zoologist or botanist (for example, Braun-Blanquet) would include western Europe from Scandinavia down to Spain, to a depth of 200 or 300 miles from the Atlantic coast; further to the east, Madame Czeczott has written an interesting paper on the Atlantic flora of Poland. The geologist now uses the word to imply certain conditions of temperature and humidity and a certain period in post-glacial time: so the term may connote either of these, or an indefinite portion of western Europe; it may have a climatic, a stratigraphical, or a geographical interpretation.

There does not appear to have been in Europe, at any time, more than slight movement due to evolution and consequent migration in the opposite direction—from west to east. This is suggested by the rarity of endemism in the flora and fauna of the British Isles. Such organisms as with us are extremely restricted in area have a range, often discontinuous, which suggests relict rather than incipient distribution; they would appear to be mostly broken up remnants of past invasions, or in some cases critical forms not yet recognized elsewhere, rather than the first colonies of new species destined to push eastward. But this may not apply with equal force to the numerous organisms which are at present confined to the most western parts of continental Europe; the flora of the Spanish peninsula, for instance, contains many elements, such as the genus *Vella*, the range of which suggests that they may have originated there.

One other general effect of the conditions prevailing along the western European coast-line may be mentioned at once. The high winter temperature has allowed of the migration northward of plants and animals which elsewhere in Europe are confined to lower latitudes,—the Mediterranean region and the Spanish peninsula chiefly. These now form a sort of tapering coastal ribbon of southern forms, many of which reach here a more northern habitat than they find on any other land. There is quite a number of plants of this type, with a greater or lesser northern range (Matthews, 1937, pp. 12, 17, 23). They constitute the Southern Element of Stapf (1914), the Mediterranean, Oceanic Southern, and Oceanic West European Elements of Matthews (*loc. cit.*). And, what is very important, they are accompanied by a group of southern animals of many kinds, having a similar northern coastal range. Mixed with these, in Ireland, especially in the west, are a small number of plants and one animal—the fresh-water sponge *Heteromeyenia ryderi*—which belong to North America. These are all of northern range there, and they are strictly north-western wherever they occur in Europe outside

Ireland, one being found in northern England, a few in Scotland, one at least in the Baltic area, and some, with additional species of the same type, in Scandinavia. They diminish in number southward, and none is found south of Kerry. Their occurrence in north-western Europe cannot, in view of their distribution in America, be attributed to the Atlantic conditions of temperature and moisture prevailing here, but is due rather to the relative proximity of their western centre of dispersal. It is the presence, often in abundance, of these, intermingled with a frequent profusion of members of the southern migration, that gives to the flora and fauna of Ireland so special an interest.

Even if we were not faced by the results of considerable instability both of the earth's crust and of climatic conditions in and around the British Isles during recent geological times, the occurrence of these extraneous elements derived from the south and from the west, as well as the absence from these islands, one or both, of many widespread continental types, would raise interesting questions. The effects of intermittent water-barriers between Ireland and Britain and between Britain and the Continent, as at present represented by the Irish Sea and North Channel in the one case and the North Sea and St. George's Channel on the other, must also be considered. The results of temperature changes of the Quaternary Ice Age, with consequent displacement of flora and fauna, added to these, raise problems regarding the age and mode of arrival of our existing plants and animals which are not at all easy of solution; they have provoked during the last century much discussion, and still evoke widely divergent opinions.

To take first the question of oscillations of sea-level Although the generally low elevation of the British Isles would have allowed submergence of most of the area as a result of relative depression of small amount, such submergence has been only very partial within the period—say from the beginning of the Tertiary—during which submergence could be claimed to have affected in any way the existing flora and fauna. Only in eastern and south-eastern England do Tertiary marine deposits point to the disappearance of that region as a land surface during much of the Eocene, Oligocene and Pliocene periods. When we take, on the other hand, the evidences of higher land-levels, resulting in the total or partial obliteration of the present sea-barriers and the production of continuous land-surfaces and consequent possibility of free migration of the continental flora and fauna into our islands much is still obscure. But it is clear that the present sea have not been nearly so persistent as the present land-surfaces As regards the British–Irish sea-barrier. If we choose to g back so far as Eocene times, it is not because the Eocene flora and fauna can have effected those of the present day save as distant ancestors, but because the Eocene outpourings of basalt in the region of the North Channel produced a solid land-bridge between Scotland and Ireland, the duration of which may have been sufficiently long to be of interest in this connection. It may well have endured through Miocene times—an era of mountain-building and high land-level. It may have persisted into the Pliocene; but we get direct evidence of a Middle Pliocene Irish Sea in the gravels containing a marine fauna of that age, which subsequently the Scottish ice of the Glacial Period pushed south-westward out of the sea-bed and over the low grounds of Wexford and Wicklow (Cole and Hellissy, 1914; MacMillan, 1938). The pre-glacial raised beach, which is a feature of the eastern and southern coasts of Ireland, lies close to existing sea-level, showing that at the time of its formation the Irish Sea, at least south of the Isle of Man, occupied the same position as at present; but save that it was formed in very early Pleistocene times, its date is still uncertain. However that may be, there is evidence that late Pliocene times found a high land-level, with free migration from Britain into Ireland, as no doubt also from the Continent into England, and a land fully stocked with a flora and fauna very like those now prevailing, derived mainly, but not wholly, from the east and south-east. The two outstanding questions as regards the relations between that flora and fauna and those of the present are the extent to which the older population has been influenced—even to the point of practical extermination as claimed by some—by the cold period, or series of cold periods, of the Ice Age, and the consequent extent of subsequent immigration necessary to produce the flora and fauna which now prevail. And, especially, the date and manner of arrival of the southern and North American elements which characterize the flora and fauna of Ireland have to be considered.

But first it is necessary to complete—so far as the incomplete and sometimes contradictory evidence or interpretation of evidence allows—the survey of water-barriers, with their alternative of land-connections. While considerations relative to isostasy, the locking up of masses of sea-water as land ice, and so on, would suggest a relatively high level of the land during the oncoming of the cold period, they would, I am informed, point to submergence during the waning of an ice-sheet, which might well continue for a prolonged time. As there is no doubt that a succession of phases of glaciation occurred, with more temperate—probably quite temperate—conditions between them, it would follow that a series of emergences and submergences may have taken place. The matter thus becomes complicated as well as problematical, and we have as yet no clear guide. But much more important than the question of land-levels during the immense length of time—perhaps half a million years—occupied by these glacial fluctuations is the existence or non-existence of land-connections in post-glacial time, by means of which fresh immigration under favourable climatic conditions might repair the damage, great or small, inflicted upon the flora and fauna by long-continued duration of low temperature. And here we find ourselves at fault. Post-glacial time is very short—perhaps 20,000 years from the final passing of the ice to the present day—a mere fraction of glacial time; and, so far as I can make out, during this limited time there is more probability that low land-levels prevailed than that land-bridges existed which might allow of extensive immigration. If Ireland were joined with Britain within post-glacial time, the connections would appear to have been restricted in area and not prolonged, insufficient in time and space for the slow migration of a great variety of plants and animals; and we are compelled to consider whether a large amount of glacial extermination is a necessary inference from what we can glean as to the condition and climate of Ireland during the Glacial Period.

I have emphasized this question of land-connections and sea-barriers because I believe—a view not universally held—that even a narrow barrier of sea constitutes a very serious obstacle to the migration of either flora or fauna—winged creatures alone excepted. In the case of plants, once in each generation the plant-body is reduced to very small dimensions—the seed, eminently suitable for dispersal. In that state the young plant is enclosed in a highly protective coat, and the protoplasm is in a peculiar condition, enabling it to endure extremes of heat and cold—some seeds, it is well known, can withstand even prolonged boiling, others have been subjected without injury to the temperature of liquid hydrogen. Seeds are usually borne in an exposed position—the summit of a herbaceous stem, the upper branches of a tree—where they will have the best chance of transport by motile agencies—for the seeds themselves are non-motile. I am referring now to the flowering plants, for the spores of cryptogams, produced in vast numbers, are so minute that they are capable of almost limitless dispersal by moving air, and may be looked on, indeed, as a normal constituent of atmospheric dust. But as regards the dispersal of the higher plants, when we look more closely into the question of the transport of their seeds across say a barrier of sea, their assumed efficiency becomes heavily discounted. The agents by which seeds may be conveyed to a distance are three—namely water, air and animals.

As regards the first, Darwin's generalization on the subject is well known—that even including dried seeds and dried branches bearing seeds not more than 10 per cent. of any flora is capable of a long sea journey and subsequent germination. This is not due to deleterious effects of sea-water, in which most seeds may be immersed without injury, so much as to the fact that a large majority sink in water, and are thus incapable of transport. The seeds which float are mostly those of riverside or seaside plants. H. B. Guppy (1906, pp. 535–538) experimented on the seeds of many British phanerogams, which, added to others which he records, gave figures for 333 species. His results accord entirely with Darwin's statement. Thinking that a more extended enquiry might yield different results, I tested the seeds of 786 British plants (Praeger, 1913), only to find the conclusions of previous observers amply justified: the seeds of 44 per cent. sank at once in water, of 57 per cent. within a day, of 87 per cent. within a week *. It is clear that transport by water under present geographical conditions could to only a very small extent help the peopling of Great Britain or Ireland by flowering plants were the present vegetation destroyed.

Transport by air also is much less efficacious than might be imagined. The seeds of the phanerogams are not nearly small enough to allow the viscosity of the atmosphere to come into play, as is the case with cryptogams. All seeds fall comparatively rapidly in air. Since little experiment on the actual rate of fall appeared to have been carried out, although a wealth of general observations and conjectures is on record, as a result of which the observers reach very different conclusions, I tested (Praeger, 1911, pp. 63–80) the rate of fall in still air of the seeds or fruits of some ninety British plants, mostly of the most light-seeded species in our flora. Among these were many of the beautiful parachute-fruits of the Compositae, other plumed seeds, minute netted seeds like those of the Orchidaceae, winged seeds like Sycamore and Elm, and minute seeds such as those of *Sagina*, *Erica*, *Orobanche*, *Juncus*. The results showed that only plume-seeded species have at all a high efficiency. Reduction of size is not carried nearly far enough in the phanerogams to allow of extended transport, nor are winged fruits efficacious. The best results were obtained from a few plants in which reduction of size of seed is combined with a plume of hairs, as in *Typha* and *Epilobium*, which are three to four times as efficient as the Dandelion fruit which is an average plume-seed. The parachutes of the Dandelion fall in still air at the rate of about

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* Fresh water was for convenience used in these experiments, tests in fresh and salt water having shown almost identical results: an observation which Guppy's tests confirm (Guppy, 1906, p. 89).

84 feet per minute. The minute seed of *Sagina procumbens* falls more than three times as fast, and the seed of *Viola arvensis* no less than nine times as fast.

The rate of fall of seeds is a measure of the distance they can travel by means of moving air, but the matter is complicated by the fact that the motion of the wind is not uniformly horizontal, but may be accompanied by upward and downward eddies. Since each upward movement must be compensated by an equal downward movement, an average horizontality of aerial motion is obtained; and the only force that can restrain the normal fall of a seed is a local excess of upward over downward currents, which cannot often happen to any practical extent. A Dandelion fruit liberated at Calais in a 60 mile an hour easterly gale could cross to the English shore in twenty minutes; but in that time the seed would have fallen 1,680 feet; that represents the amount by which upward eddies must exceed downward eddies during the journey if the seed is to arrive at the same height above the sea at which it started. So far as observation goes, it is seldom that over sea there is any noticeable excess of upward over downward currents, so the chances in favour of our Dandelion are exceedingly small. What chance is there for seeds that are many times as heavy? *Lathyrus pratensis*, for instance, would fall nearly eight miles in the same time. Clearly normal transport by wind may for practical purposes be ruled out except for a few especially efficient seeds and for narrow barriers.

There remains the question of transport by animals; and where a barrier of water intervenes this is almost limited to the agency of birds. That frugivorous birds are most efficient aids to the dispersal of seeds there can be no doubt; this applies especially to plants with fleshy fruits. "The seed-eaters are not the seed-planters; on the contrary, the insectivorous birds more often sow seeds than the true-seed-eaters. . . Seeds which *simply contain* nourishment are eaten and destroyed, while seeds which *are contained in nourishment* are eaten and survive" (Barrows, 1890, p. 281). It is not the digestive juices which destroy eaten seeds, but the crushing of them. A survey of the extensive literature bearing on this question shows that, subject to this important qualification, frugivorous birds are clearly efficient agents of dispersal over barriers, provided these barriers be not wide, for the digestion of birds is very rapid; migrating birds, it has been found, arrive empty of food and without seeds adhering to their feet or feathers.

It must be emphasized especially that success will not follow merely from the surmounting of a barrier. The main difficulty—that of successful colonization—still confronts the immigrant. Unless the new arrival is better fitted to hold the ground than the plants or animals which are already in possession of it, failure awaits it. This is a very important point, which has been emphasized by de Candolle (1855, II, p. 623) and many subsequent students of both faunal and floral migration.

The flora of Ireland as compared with that of Britain, and of Britain as compared with that of adjoining continental countries, does not display any undue proportion of those plants which, by having floating seeds, might have arrived by water; or those which, having flying seeds, might have come by air; or those which are eaten but not destroyed by birds, and might therefore have arrived by their agency. And in view of the relatively short period which has elapsed since the final retreat of the ice allowed the re-entry of the plants which had been driven out, or of others, we might imagine that had this re-entry included a large portion of the flora, and had it been across the existing water-barriers, a preponderance of species suited to trans-marine migration might still be detected. No such preponderance is noticeable, which, so far as the argument is admissible, suggests immigration of the flora by land.

The case for terrestrial and not trans-marine immigration is greatly strengthened when we consider the fauna. Animals have no resting-stage comparable to the seed, a structure specially well adapted to adventure. The egg, indeed, is a phase during which the animal is at least withdrawn into a small compass, as in the seed. In such creatures as snails and woodlice—terrestrial animals devoid of wings and of other facilities for rapid or lengthy journeyings, and on these counts well worthy of study in this connection—the eggs are fragile and delicate structures, carefully hidden in places usually damp, and often attached to some fixed object; they are of no service for dispersal; dispersal takes place during the active and motile existence of the parent. But the invertebrates mentioned, as also the group of worms and many others, are mostly of limited and special habitat, are easily injured by sea-water or by exposure to extremes of heat and cold, and are not fitted for anything but slow and cautious migration. To these a barrier of sea must be an even more formidable obstacle than to the resistant though non-motile seed. I have little doubt that when the distribution, habits, dispersal and so on of the invertebrates are better known they will be found to furnish information relative to past history and migrations more valuable than what we can hope to obtain from the plants. To my mind a survey of both terrestrial plants and animals raises very great difficulties as to trans-marine migration on any considerable scale, and leads us to look for land-connections in order to account for the present peopling of these islands.

That land-connections have existed during a good deal of recent geological time is clear, and question follows as to the period or periods of immigration ; this brings us up against the difficult problem of the influence of the Ice Age upon the pre-existing flora and fauna. How much was exterminated at that time ? How much survived ? And since retreat southward from the advancing ice was in Ireland cut off by the ocean, how much re-colonization was necessary from the east and south-east—ever the main reservoir from which Ireland was supplied—and how and when was this accomplished ?

Edward Forbes (1846), whom I must regard as still the most brilliant student of this subject, writing nearly a century ago, was led by the evidence supplied by present distribution in Ireland of plants and animals to conclude that at least certain groups, among which he included the southern or Lusitanian element, survived the Ice Age within that country, while the bulk of present plants and animals owe their presence here to terrestrial immigration in post-glacial time. He accounted for the comparative poverty of the Irish flora and fauna in relation to those of Britain by the breaking down of the Irish–British land-connection prior to the severance of Britain from the Continent ; thus immigration into Britain continued for some time after immigration thence into Ireland had been interrupted. While Irish naturalists, well acquainted with the local flora and fauna and its distribution—R. F. Scharff, G. H. Carpenter, N. Colgan, R. W. Scully, A. Farrington, R. Southern, A. W. Stelfox and others, including myself—have been led by long observation to maintain the accuracy of Forbes' view, widely divergent opinions have been expressed by competent observers. Thus, Clement Reid (1911), accepting unhesitatingly the doctrine of the practically complete extermination of plant and animal life throughout the British Isles during the period of maximum glaciation (he makes a possible exception of a few arctic species), does not even ask for later land-connections, but completely re-stocks Britain and Ireland with plants by means of 'chance introductions of seeds during thousands of years'. 'Seeds', he says, 'are evidently brought from the Continent and scattered broadcast over certain coastal districts, and they grow and spread where climate and soil are suitable'. It is to be assumed that the whole of the present fauna, which he does not mention, arrived similarly. J. Kaye Charlesworth (1930) also believes in almost complete extermination. According to him a mild Aurignacian interglacial period allowed the reconstruction over a land-connection of a flora and fauna practically exterminated by the almost universal ice-sheet of the period of maximum glaciation; but this new flora and fauna was itself almost entirely destroyed by the subsequent Magdelenian glaciation. All our present plants and animals, with the possible exception of some arctic forms, entered Ireland over a plain of drift with a narrow water-barrier where the Irish Sea now stretches, after the ice had finally passed away. Both Reid's and Charlesworth's papers are characterized by a confidence of statement relative to disputed matters, and by sweeping generalizations, that do not accord well with the admittedly difficult and complicated nature of the problem, and with our very incomplete knowledge of many of the factors involved.

Dr. Stapf (1916–17) and J. R. Matthews (1926) also, among recent writers, claim the practical extermination of life in glacial times, and re-colonize Britain and Ireland by post-glacial overland migration. While Matthews concedes that the Lusitanian element of Ireland and south-western England represents the oldest arrivals, he still makes this group post-glacial in its migration. Stapf, while denying the possibility of his southern element (which includes the Hiberno-Lusitanian plants) having survived the rigorous conditions often postulated, adds a saving clause: 'If in the future new facts should come to light which make the climatic conditions during the Glacial Period appear more favourable for plant life, the question of survival will have to be reconsidered' (1916–17, p. 81).

On the other hand, A. J. Wilmott (1930) finds the evidence for highly rigorous conditions during the Ice Age unconvincing. He sees in the existing flora much that points to very early migration, and combines with the body of Irish observers in claiming the survival through Glacial times of a good deal of the existing flora, including the Lusitanian element. In this he is joined by Roi (1936) and others.

The crux of the problem is clearly contained in (1) the question of habitat—i.e. of ice-free land—during the various phases of the Ice Age, and (2) the question of minimum temperatures during the same period. It should be pointed out that the effect of minimum temperature must be considered in relation to that of snowfall. Should a covering of snow be a normal winter condition low temperatures lose much of their sinister significance.

If it be assumed that a practically universal ice-sheet prevailed, coupled with temperatures so low as to inhibit the presence of all but arctic plants and animals, then we must of necessity fall back on vigorous post-glacial immigration. But what is the evidence on which extermination is demanded? There is no certainty of a simultaneous glaciation of the whole of Ireland. There was a main glaciation during which the ice spread southward as far as Cork, but no farther. Later, a local glaciation, spreading from the south-west, extended in turn about as far as Cork, with only local glaciation elsewhere. A second general glaciation has left its moraines three-quarters way down Ireland, along a line passing from Wexford to the mouth of the Shannon, the southern quarter having been ice-free. In addition, there seems good reason for assuming the presence of an ice-free strip down the west coast during both glaciations, broadened perhaps by a marginal bulge such as is known to result from the heavy loading of a land surface with ice. There is also increasing evidence in various glaciated regions—Ireland, England, North America—of the presence of ice-free areas well within the margin of ice-sheets. The evidence for this is twofold—the absence of the usual signs of glaciation and the presence still of plants believed to be of pre-glacial age. In Ireland R. Southern (1909) is driven to postulate ice-free areas in order to explain the presence and distribution of certain earthworms. Another mild inter-glacial period succeeded, and any subsequent glaciation was quite local. In the above recapitulation of glacial changes and glacial conditions, given me by A. Farrington, we find no necessity for inferring extermination, unless extremely low temperatures prevailed, and there is no need to postulate this. For the production of an Ice Age excessive cold is not required, only excessive precipitation accompanied by a moderate degree of cold; a temperature well above that in which plant and animal life would be reduced to only the hardiest forms might still result in the formation of an ice-sheet. G. C. Simpson (1930), indeed, argues that an ice-age may be caused by *an increase* rather than a decrease of solar radiation, and Brockmann-Jerosch (1920) on different grounds concluded that an oceanic climate combined with increased precipitation gave the requisite conditions. R. F. Scharff was so impressed with the incompatibility of all-pervading ice and extreme cold with the evidence provided by the present flora and fauna that he attempted to substitute mud for ice as the agent of the visible effects of 'glaciation'.

But admitting the existence of a great ice-sheet over almost the whole of Ireland, we may compare the present state of Greenland, one of the most heavily glaciated areas in the world, which nevertheless possesses a flora of over 400 flowering plants and pteridophytes, which include many familiar lowland species of British and Irish meadows and woods: in addition there are over 1,500 mosses, lichens, and lower forms of vegetable life. Can it be claimed that Greenland at present, with its more northerly situation, its limited insolation, its colder seas, its vast ice-cap, is more favourably situated than Ireland would have been during the Ice Age, with its more southern position, higher sun, and warmer seas? And Ostenfeld (1926), who made a special study of the composition and distribution of the present Greenland flora, claims that 60 per cent. of it survived the Ice Age in its present position, and that, even far inland, ice-free and populated areas existed during the period of maximum glaciation, even as they still exist. But he considers that the plants of northern Greenland, 'the most northerly vegetation known', probably migrated southward with the advance of the ice, and have re-migrated northward in post-glacial time (Ostenfeld, 1929, pp. 1509–1510). Terra del Fuego repeats and confirms the facts gained from a study of Greenland—that proximity to a great ice-sheet by no means connotes the inhibition of all but arctic forms of life. On the evidence at present available it does not seem reasonable to assume the almost complete extermination of Irish plants and animals owing either to paucity of ice-free land or to extreme lowness of temperature. The same postulate applied to England would allow of the survival of a considerable part of its flora and fauna on the large admittedly ice-free area south of the Thames. I think this picture probably comes much nearer the truth than that which would envisage in southern England only such plants as *Salix polaris* and *Betula nana*.

What about the history of those groups, the Lusitanian-Mediterranean and the North American, which add so special an interest to the British and particularly to the Irish flora and fauna? As to the former, most of the species are on the Continent confined or nearly so to the Spanish Peninsula, though some run far along the Mediterranean and a few extend into south-western France. Several (*Sibthorpia*, *Euphorbia Peplis*, *Glyceria Foucaudii*) are on the English south or south-west coasts, a few others (*Erica ciliaris*, *E. vagans*, *Pinguicula lusitanica*, *Euphorbia hiberna*, *Simethis planifolia*) are in Britain south-western only. All these except *Erica ciliaris* reappear in Ireland, mainly in the south and west, with two foci situated in Cork–Kerry and Galway–Mayo; several extend north to Donegal; *Erica vagans* s in Fermanagh in the north-west, *Glyceria Foucaudii* in Down as well as on the Shannon estuary. Most are distinctly calcifuge. In addition to these there are in Ireland *Saxifraga spathularis* (*S. umbrosa* auct.) (Wicklow, Tipperary, Waterford, and thence by Kerry to Donegal), *S. hirsuta* (*S. Geum* auct.) Cork, Kerry, and as *S. hirsuta*×*spathularis* in Mayo), *Arbutus Unedo* (Cork, Kerry, Sligo), *Erica Mackaii* (Galway), *E. mediter-anea* and *Dabeocia polifolia* (Galway, Mayo), *Pinguicula randiflora* (Cork, Kerry, Limerick); and *Neotinea intacta*, the only calcicole species, is in Clare, Galway, Mayo. Of the British members of the group, *Erica ciliaris* alone is absent. Most are lowland (under 500 feet), but six species ascend the hills to heights ranging from 1,700 to 3,370 feet. Almost all have a patchy and restricted range, and with the exceptions mentioned all in Ireland hug the southern and western coasts rather closely. This is not altogether an effect of the high winter temperature prevailing there (42°–44° F., January), for on the hills a number of them live in temperatures lower than those which are found over any portion of the Irish lowlands. Nor is it entirely an edaphic effect, for though the great Central Plain of limestone interposes, to the east of the coastal metamorphic areas, avenues of non-calcareous rocks, such as most of these plants effect, and a profusion of peat areas extend eastward across the country in both north and south, the high humidity which prevails in their chosen haunts has probably a greater part in defining their eastern limits than either temperature or soil.

There is certainly a difficulty in conceiving some of these southern forms weathering in their present habitats conditions much more inimical than those to which they are subject at present. But we know very little of the capacity of plants to withstand what on present evidence we consider unsuitable conditions. In Clare *Neotinea* and *Adiantum* flourish amid *Dryas* and *Gentiana verna*; in late-glacial times in Ireland Spotted Hyaenas are recorded as having preyed on Mammoths; and the Tiger roams in Siberia as well as in tropical forests. If there were no eye-witnesses to such things, would we believe them? The presence or absence of these species may well be due to factors other than temperature.

We must assume that the southern forms reached the British Isles by overland dispersal. Direct migration would involve passage across sea of some 400 miles. The plants are not as a group specially small-seeded or light-seeded. The seeds of all, with the exception of *Neotinea*, fall rapidly in air, and all which have been tested sink in water; and there is no reason to think that birds have provided assisted passages, though one—*Arbutus*—has a fruit that is eaten by birds. But if they came by land we are puzzled by the manner in which so many of them are congregated at the northern end of their line of march. We might perhaps have expected rather a progressive diminution in number from their southern home northwards, as is noticeable in the larger 'Southern Element' of Stapf. Stapf would set down the present group as merely the western wing of a general invasion from the south their marked discontinuity being due to extreme disintegration of area since their arrival here in post-glacial time. Eight of the group as enumerated above occur in southern and south-western England ; but all of these with one exception, nd eight others as well, have reached Ireland. Did the atter eight also in their time pass through south-western England and subsequently become extinct there ? No omparison of conditions prevailing, say, in Cornwall and n Kerry would suggest such extinction. We have besides he fact that one of the most marked of the Kerry plants, *Pinguicula grandiflora*, when introduced into Cornwall, spread with extraordinary rapidity. Or did they migrate long a shore-line lying further west and now destroyed ? If we believe that they are an ancient group, that appears o me a more reasonable solution. If the coast at the time of their migration stood where the 50-fathom line now extends hat shore would lie not far from the present Kerry, but would pass well to seaward of Scilly ; and were the plants s maritime in their proclivities as they are in Ireland to-day hey might possibly have succeeded in falling back into Kerry nd Connemara as the sea-edge advanced yet have failed n the longer retreat into Cornwall.

This view of the matter is emphasized when we consider he corresponding group of animals. These include two molluscs (*†*Helix pisana*, *Geomalacus maculosus*), a beetle (*Otiorrhynchus auropunctatus*), a hemipteron (*Aëpophilus onnairei*), a neuropteron (*Agapethus delicatulus*), a false-scorpion (*Obisium carpenteri*), five woodlice (*†*Eluma purpurascens*, †*Metoponorthus melanurus*, **M. cingendus*, †*Philoscia couchii*, *Trichoniscus vividus*) ; and no doubt others remain o be discovered among the smaller invertebrates. Some others, indeed, with the same suggestive range, are on record, but what with the probability that their distribution is not yet fully known, and in some cases doubt as to their identity, t seems better to withhold them for the present. These are n Ireland almost equally western, eastern and southern, nd they are not altogether absent from the north. The hree marked with an asterisk alone extend to England, n which country they are south-western in their range, except hat *Agapethus* occurs only in the Scottish Arran ; elsewhere he group is found in south and south-west Europe (Mediteranean, Spain, Portugal, France). They are a more southern roup in habitat than the plants, four of them (marked with dagger) being found in one or more of the groups of islands Canaries, Madeira, Azores) that lie in the Atlantic in lat. 8°–40°, far to the south or west of Spain, while *Dabeocia* n the Azores) is the only corresponding plant. Their present istribution suggests antiquity, since, as has been pointed ut, such animals are singularly ill-adapted in all stages of heir life-history for dispersal across sea.

The American group, which in Ireland mingles in a perplexing way with the southern organisms just dealt with, is of northern type; and since none of the species occurs in Siberia, they would appear to have arrived by the shorter Atlantic route, presumably *viâ* Iceland and Greenland. None of them occurs in Europe south of Ireland, but in that island we find *Sisyrinchium angustifolium*, *Eriocaulon septangulare*, *Naias flexilis*, all with a wide range along the west coast, *Juncus macer* the same and also in Wicklow, *Spiranthes gemmipara* in the south-west, *S. stricta* in the north-east, also the recently distinguished *Myriophyllum alterniflorum* var. *americanum* of Pugsley (1938), which is the prevailing if not the only form in North America and in Europe is so far known only from Lough Neagh, Lough Ree and Lough Derg in Ireland. Their northern facies is emphasized by the occurrence of *Spiranthes stricta* in Colonsay, of *Eriocaulon* on the western Scottish isles, and of *Naias flexilis* in Skye and Perth as well as in Lancashire and in the Baltic region. A second American rush, *Juncus Dudleyi*, recently found in Perth, is so far unknown elsewhere in Europe. The Scandinavian flora reinforces this American-European group by several additional species—*Ranunculus Cymbalaria*, *Rhododendron lapponicum*, *Campanula uniflora*, *Pedicularis flammea*, *Carex scorpoidea*, *C. nardina*, as also by the fossil remains of *Dulichium spathaceum* and *Brasenia purpurea*, now no longer in Europe (Jessen, 1934). Another plant, the orchid *Habenaria straminea*, closely allied to our *H. albida*, has advanced from Newfoundland by Greenland and Iceland to the Faeroes, and still holds this territory, just failing to reach Shetland and thence Scotland. One animal, the fresh-water sponge *Heteromeyenia ryderi*, found in western Scotland and all over Ireland, also belongs here. However these American plants reached Europe, their very patchy and discontinuous distribution points to early arrival, undoubtedly, to my mind, pre-glacial. It must be noted that there is a corresponding group of European plants found over a limited area of north-eastern North America, which clearly represents a similar migration in the opposite direction. This includes, for instance, *Pedicularis sylvatica*, *Potentilla procumbens*, *Montia rivularis*, *Sieglingia decumbens*, all common in western Europe, but in America limited to Newfoundland and the St. Lawrence vicinity—the parts that make the closest approach to Europe (Fernald, 1929, p. 1501). An excellent example of a similar range among animals is furnished by the snail *Helix hortensis*, a west European species spreading by the British Isles, Shetland, the Faeroes, Scandinavia, Iceland and Greenland to an extensive coastal area around the Gulf of St. Lawrence, where its occurrence also in Pleistocene deposits shows that it is not a human introduction, as was suggested (Johnson, 1906, p. 73; Dall, 1905, p. 20; Scharff, 1909, p. 18).

It is impossible that these plants and animals can have come directly from America to the British Isles or to northern Europe, or vice versa across the existing seas. The two species of *Spiranthes* alone have, in their loose netted seed-coats, any character to reduce a high rate of fall, and even the very light seeds of Orchids fall in air at a rate of the order of half a foot to a foot per second. The seeds of those of the Irish-American group which have been tested all sink in water—*Eriocaulon* has a particularly heavy seed—and direct transport by birds is out of the question. The boreal facies of all the species points to this Atlantic route. *Sisyrinchium angustifolium* has actually been found recently in southern Greenland, but the discoverer, Dr. Iversen, inclines to the view that it is a relic of journeyings between Vinland (on the southern side of the St. Lawrence) and Greenland by the Norsemen about the year 1000 A.D. (Iversen, 1938). The present seas which separate America, Greenland, Iceland and Europe from each other are deep and wide, and to postulate continuous former land would, so far as I can find, throw the date of migration back to a very distant and indefinite time—probably Eocene. But there seems cause to believe that a considerably higher relative land-level may have existed in the late Pliocene. The greatest elevation that can in reason be allowed would not by any means do away with the present sea-barriers, but it would lessen them. They would still be very serious deterrents to migration; but the plants and animals must have got across somehow, and no other more likely route can be found. To invoke in this connection an Atlantis or other fanciful creation recalls too vividly Darwin's gibe about 'making continents as easily as a cook does pancakes', and 'sinking imaginary continents in a quite reckless manner' (Darwin, 1887, II, p. 74, and III, p. 230). We must admit that the whole matter of these migrations bristles with difficulties, among which at present we are merely groping.

To revert to the general subject. The indigenous flora of Ireland is small—a little over 1,100 species of Phanerogams and Vascular Cryptogams, on the standard of the 'London Catalogue'. The corresponding flora of Britain, whence the Irish flora was for the most part directly derived, falls not far short of double that amount. Much of the discrepancy is to be attributed to the difference of area— more than two to one—and of climate, particularly the relative range in latitude (eleven degrees in Britain against four in Ireland); also the greater diversity of surface and soil in the larger island. But scrutiny shows that these differences will not wholly explain the paucity of the Irish flora. The wide range in Britain, both horizontal and vertical, of many species which are absent from Ireland indicates clearly that they would have invaded that country had they been able. As instances, *Genista anglica*, *Chrysosplenium alterniflorum*, *Paris quadrifolia*, *Avena pratensis* may be quoted, and there are many others. It seems clear that, as Forbes maintains, westward migration from Britain was arrested by the Irish Sea while migration into Britain from the Continent still remained open. The final breakdown of the Irish–British connection occurred at a date earlier than that of the British–Continental connection. And the fauna supplies stronger evidence on this point than does the flora, in the absence from Ireland of common and widespread British animals such as the Roe-Deer, the Mole, the several Voles, the Weasel, Polecat, the Common Shrew, the Common Toad, the Ringed Snake, the Adder, Slow-worm, Palmated and Crested Newt, Barbel, Chub, Dace, and others, to quote vertebrata alone. These, like the plants, it would seem clear, were able to invade Britain across land-surfaces, but were brought up in their westward spread by the subsidence which produced the present Irish Sea.

Very interesting is the case of plants which have just effected an entry into Ireland, but have not succeeded in making good there. Since migration goes on continually, though very much slowed down by a barrier of sea, we have in these cases to choose between relict or incipient local endemism. We may be tempted to regard as recent arrivals some plants which in Ireland are confined to the eastern coast, such as *Geranium pratense*, *G. sylvaticum*, *Melampyrum sylvaticum* and *Carex pauciflora*, all in Antrim, close to Scottish stations. Other cases, such as *Trifolium glomeratum* and *Asparagus maritimus*, found in Ireland only on the south-eastern coast, are less suggestive, since these plants favour edaphic and climatic conditions which they might not find elsewhere in this country. Some other cases are clearly relict—northern plants like *Rubus Chamaemorus*, *Saxifraga nivalis* and *Epilobium alsinefolium* (left stranded on the mountains when the ice of glacial times retreated, and each now reduced to one small colony), northern animals like *Agabus arcticus*, *Teratocoris viridis*, *Mysis relicta*. But how are we to account for the single small patch on a bare limestone hill far from houses or cultivation in western Donegal of *Helianthemum vulgare*, a very widespread British plant, or the one small patch of *Adoxa Moschatellina*, so common in Britain, in rough ground on the Cave Hill near Belfast. The latter might only have had to cross the Irish Sea to reach its present station, but the former would need to get across Ireland in addition.

The Irish flora supplies examples of discontinuous range more puzzling than these. *Hydrilla verticillata*, an ally of the North American *Elodea canadensis*, is found in Australia, Madagascar, Central Africa, Asia, Russia, Pomerania, in Esthwaite Water in Lancashire, and in Ireland in profusion in Renvyle Lough, a small lakelet on the edge of the Atlantic in West Galway. The English plant, and apparently the Irish also, never flowers, and it is so slender and delicate that a branch of it removed from the water is dry and dead in a very short time. Its distribution presents surely an extraordinary problem; its whole range suggests very early dispersal.

Another notorious puzzle is *Inula salicina*, widely spread in Europe, absent from the whole of Britain, and in Ireland occupying only the stony shores of Lough Derg near the centre of that country. It is a plant with an efficient parachute-seed, and one wonders whether very exceptional long-distance post-glacial dispersal accounts for its presence. The case of some of the ferns, too, is peculiar—fairly widespread in Britain, in Ireland confined to a single hillside, like *Phegopteris Robertiana*; or occurring as widely scattered single plants occupying sometimes a clearly temporary habitat, like *Cryptogramme crispa* and *Phegopteris Dryopteris*; or making a brief and ephemeral appearance in the country like *Lastrea rigida*. But the ferns are in a different category from the flowering plants, on account of the extreme lightness of their spores, and I am inclined to account for these and similar anomalous occurrences as due to occasional introduction by air from across channel into places which for some not obvious reason are unsuitable to the species. As regards the ferns at least these peculiar cases are, I take it, eccentricities of recent origin such as on examination we are bound to find in any flora at any period. Every flora, and every fauna also, has its puzzles, and we are fortunate if we can elucidate the broader and simpler problems without worrying over its special conundrums.

On the other hand, it is of interest to note that there are a number of plants which have achieved in Ireland a greater success than in the sister island, although some and probably all of them must have passed across Britain to get there, and must have had—unless exterminated during the Glacial Period in Britain but not in Ireland—a longer time in which to colonize the more eastern island. Thus *Rubia peregrina* occurs in 42 per cent. of the forty Irish vice-counties, in only 22 per cent. of the 112 British vice-counties; the proportion in the case of *Orobranche Hederae* is seventy against twenty-one; of *Scirpus filiformis* fifty against eleven; of *Equisetum trachyodon* forty against one. In a number of cases preponderance in Ireland may be attributed to the greater humidity of the climate or the larger proportion of bog and marsh prevailing there: thus, *Lathyrus palustris*, *Andromeda Polifolia*, *Utricularia intermedia*, *Rhynchospora fusca*, *Lastrea aemula*, *Trichomanes radicans*, taken together, show an average occurrence of 56 per cent. in Ireland, of only 17 per cent. in Britain. The greater uniformity in Ireland of conditions of temperature and moisture as compared with those in the other more extended island no doubt tends to emphasize these differences; the diversity of flora between Caithness and Sussex is considerable, between Antrim and Kerry less. But many of the cases have no obvious explanation.

Note should be taken of the occurrence in quite recent times of a slight change of climate which, though known only from what one may call its fossil effects, may well have influenced both the present flora and fauna. This was what is well known as the Neolithic climatic optimum. Northern forms still lingering, relicts of glacial times, may well have received then their coup-de-grâce, though a few of their companions are still with us; and southern forms, encouraged by the slight amelioration of climate, may have pushed northward into stations in which, with the return of colder conditions, they can now scarcely maintain themselves, as is known to have occurred in the case of certain local marine mollusca.

What would be, were the records in existence, the direct and obvious way of studying the history of the flora, namely by the investigation of bygone vegetations, can be used to only a limited extent, since plant-remains under most conditions become disintegrated and disappear. The chief exception in this regard is peat, and peat, owing to the restricted and specialized character of the bog vegetation, helps but little in the reconstruction of the general flora, although bog investigations are invaluable as elucidating, through the study of tree pollen, the forest succession and thence the climatological and geological history of glacial and post-glacial time. Other deposits rich in plant-remains are few and not easily discoverable, and the identification of the contained vegetable matter is a difficult undertaking, of which an efficient technique has only recently been perfected. A good deal of work on quaternary floras is now in progress in Britain, and in Ireland we had recently the valuable services for two seasons of Prof. Knud Jessen, during which he taught Irish students to continue his investigations into our recent plant-bearing deposits. Results are now beginning to appear, and already it is evident that valuable light may be thrown on vexed questions like the age and route of migration of such important elements as the Lusitanian and American groups, as well as the survival or restoration of the flora in connection with the Ice Age.

Work on cave deposits has shown that in late-glacial and early post-glacial times there was in Ireland a considerable fauna of large herbivores and of carnivores which preyed upon these—Mammoth, Great Irish Deer or Irish Elk, Reindeer, Brown Bear, Spotted Hyaena, Wolf, Arctic Fox, Lynx. The presence of remains of these, often in abundance, connotes a vegetation profuse in quantity if not in variety. Of this flora we still know very little, but already some interesting points have emerged. Thus, there would seem to have been in Ireland since those days a western movement. *Naias flexilis*, the only one of the American group of which fossil remains have so far been found, now confined to stations close to the west coast, had formerly a much more general extension. And while in the British Isles it has forsaken Cardigan (Godwin and Mitchell, p. 447) as well as eastern and central Ireland, its movement in north-western Europe has been a shrinking from Scandinavia and Finland south-eastward towards the southern shores of the Baltic. *Arenaria ciliata*, now confined in the British Isles to a small area overlooking the Atlantic in Sligo, was formerly in Dublin; *Thalictrum alpinum*, *Oxyria digyna*, *Juniperus communis* are now confined to west and north Ireland, and *Potamogeton filiformis* has moved northward and westward; all four were former Dublin plants. A body of information on these lines may be hoped for soon which will allow of important generalizations that may throw a flood of light on the history of our flora, as also of our fauna. Already, I think, it has given the death-blow to that school of thought which has seen in the presence of our Lusitanian and American plants a result merely of trade and other human intercourse within recent times.

The paucity of endemic plants in Britain as well as in Ireland has been referred to as a natural consequence of short and merely intermittent insulation. Wilmott (1930, p. 187) has reduced the list of supposed endemics to due proportions. There remains a number of plants—species according to the modern view, subspecies or varieties on the standard of Linnaeus or Hooker—which appear to be confined to these islands, mostly to southern England; very few—e.g *Arabis Brownii*—to Ireland. These have originated here, and, post-glacial time being considered too short for their evolution, Wilmott (p. 190) claims that they must have survived the Glacial Period, stating that in all cases they appear to occur only in or near areas that were ice-free. In Ireland evidences of incipient endemism are not infrequent. For nstance, both Moyle Rogers and Riddelsdell have commented on the fact that Irish *Rubi* very seldom entirely conform to British types; they have a kind of Hibernian perversity about them, and do not conveniently fit into English pigeonholes.

I have found the preparation of this lecture troublesome on account of the necessity for extreme condensation. To attempt to deal within the limits of an hour or so with a subject which in its various aspects would need a course of lectures for its proper development is not comfortable, and I feel that I have not been able to clinch a single argument, or to display adequately the pros and cons of any of the questions raised. And this is eminently unsatisfactory: 'Les données du problème', writes J. Roi (1936, p. 433), in introducing the subject, 'sont infiniment complexes; pour peu que l'on omette un détail, on risque défausser l'ensemble'. All that has been possible has been to give a very brief view of the matter of the relationships of the Irish flora and fauna as they appear to me at present. This brevity is not to be deplored when one considers the clouds of uncertainty which still surround the action of most of the factors, whether geographic, climatic, or edaphic, which have moulded and continue to mould the distribution of our plants and animals. The work of recent years has revealed new facts which cause detailed statements of the last generation to be no longer valid. Too great detail in our treatment of the subject to-day would merely court a similar fate in the near future.

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Further useful references to the subjects discussed will be found in several of the above papers: for instance, Charlesworth, Matthews, 1926 and 1937, Praeger, 1911, Roi, Wilmott.

REVIEW OF THE SOUTH AUSTRALIAN REPRESENTATIVES OF THE GENUS CORREA, WITH DESCRIPTIONS OF THREE NEW SPECIES.

By Edwin Ashby, F.L.S.

[Plate 4]

All descriptions and measurements are from living examples growing in the 'Wittunga' garden at Blackwood, South Australia. All colours were taken in sunshine, and the names of the colours are from 'Ridgway's Color Standards'. In all descriptions (unless otherwise stated) a pocket lens of twenty magnifications, linea, has been used. In all the species there are eight stamens, of which four are a little shorter. The word 'pubescent' is used in its original meaning, namely, numerous very short hairs. 'Tomentose' is used for longer hairs (the original meaning was 'a small piece of sheep wool'), the word 'downy' is supplied as a meaning of both in 'Manual of Botanic Terms', which is misleading and inexact.

I have much pleasure in acknowledging my indebtedness to Mr. R. A. McLean, B.A., Dip. Ed., of Blackwood, in the preparation of the Latin diagnoses accompanying the descriptions.

Material from the type-plants can be consulted in the herbaria of the Royal Botanic Gardens, Kew, London, the Adelaide University herbaria, and the Waite Research Institute, Adelaide, South Australia.

Key to South Australian members of the genus, with the addition of C. aemula.

- Petals separating after flower is expanded.
  - Calyx with four lobes longer than the tube.
    - Peduncle thick (about 1·5 cm. long); branches dense with long, silky, branching hairs .... *C. aemula.*
    - Peduncle slender (about 2–3 cm. long); young branches with rigid, caducous, stellate hairs; older branches glabrous .... *C. affinis.*
  - Calyx truncate, with or without teeth .... *C. alba.*
- Petals coherent, at least in the middle portion, until they fall off, the limb spreading.
  - Calyx 4-toothed (Black records sometimes absent) .. *C. rubra.*
  - Calyx 4-lobed, lobes short.
    - Flower short, green; lobes under 5 mm. long ... *C. reflexa.*
    - Flower long, green or pinkish; lobes about 12 mm. *C. calycina.*
  - Calyx not toothed and almost glabrous.
    - Flower scarlet, broad, slightly campanulate; lobes spreading .... *C. neglecta.*
    - Flower not campanulate, narrowly tapering from lobes to calyx; lobes spreading, recurved ... *C. neglecta* [var. *minor.*
  - Calyx not toothed, pubescent.
    - Flower Amaranth purple, lobes yellowish-green; stamens extruded .... *C. Turnbullii.*
  - Calyx 8-toothed, colour as in *C. Turnbullii*; stamens extruded .... *C. decumbens.*

. C. AEMULA (Lindl.) F. Muell., Fragm. I, p. 3, and Pl. Vict. I, p. 139, t. 7. (Pl. 4, fig. 1.)

Tall shrub with densely tomentose branches, the tomentum being chiefly composed of long silky branching hairs. *Leaves* thick, broadly ovate, 2–7 cm. long, scabrous above, each minute wart surmounted by a stellate hair, paler beneath, thickly beset with soft stellate hairs. *Flowers* pendulous; peduncle 15 mm. long, thick with loose tomentum similar to that of the branches, with two ovate bracts about 10 mm. long, placed about 5 mm. from the base of the peduncle; calyx-tube 5·5 mm. long and lobes about one and a half times as long as the tube and narrow, sparsely covered with long stellate hairs; flower-tube with lobes 32 mm. long by 7 mm. wide, petals free, colour 'Light Chalcedony Yellow' at the base, 'Tea Green' (Ridgway) towards the lobes, purplish in fading flower, thickly sprinkled with white stellate hairs. *Stamens* glabrous, dilated at base; anthers only extruded beyond the lobes; anthers yellow.

Grampians of Victoria. Not yet found in S. Australia.

2. C. AFFINIS E. Ashby. *C. aemula* J. M. Black: F. Muell. in J. M. Black, Fl. S. Austr. pp. 340 and 692. Not of Lindley. (Pl. 4, fig. 2.)

Tall shrub with slender practically glabrous branches except the very young portions which have rigid caducous stellate hairs, both stalked and sessile. *Leaves* thin in texture, shortly petiolate, elliptical-ovate, recurved, acuminate, tomentose with sessile semi-stellate hairs sparse above and more scattered beneath. *Flowers* pendulous, mostly solitary; peduncle 18 mm. long, very slender, glabrous with two small (2·5 mm. in diameter) orbicular bracts at the base and two linear bracteoles placed about 5 mm. from the other end; calyx cup-shaped, persistent, 4-lobed, with a few minute seemingly accidentally scattered stellate hairs, otherwise both calyx-tube and lobes are glabrous; calyx-tube and lobes of equal ength, lobes shorter and broader than *S. aemula* and spreading; petals 4, valvate, much longer than the calyx-tube, sparsely pubescent on outside, becoming almost glabrous in the lower third; tube and lobes 'Tea Green' (Ridgway), narrow, half width of flower-tube in *C. aemula*, 25 mm. long to tip of lobes, obes at first 5 mm. long, usually not spreading but as flower fades becoming more or less free. *Stamens* 8; only anthers exserted; filaments slender, glabrous; the anthers without erminal appendages. *Carpels* 4, 2-ovulate; style long, lender, with small bilobed stigma; disk shallow, 8-lobed; ruitlets normally 4, 1–2-seeded, obtuse.

Mount Lofty range; Barossa range; Myponga; Kangaroo Island.

Correa affinis, sp. nov. *Frutex* procerus; ramuli foliaque juvenilia tomentosi modo. *Folia* subverticillata, elliptico-ovata, recurva, acuminata, 20 mm. longa, c. 13 mm. lata, utrinque pilis sessilibus stellatis partim pubescentia. *Flores* penduli; pedunculus 15 mm. longus, gracilis, glaber, basi bracteatus, tum bracteolis indutus; florum tubus *C. aemulo* angustior; lobi plerumque non expandentes. *Calyx* campanulatus, lobis 4, persistens, fere glaber, perpaucis pilis, 4 mm. longus. *Petala* 4, 25 mm. longa, valvata, multo calycis tubo longiora, extus parce pubescentia. *Stamina* 8, antheris solum exsertis. *Stylus* longus et gracilis; *stigma* bilobatum. *Fructus* (carpelli) plerumque 4.

3. C. ALBA Andr. (Pl. 4, fig. 3.)

Coastal shrub, the branches covered with a grey or rusty tomentum. *Leaves* ovate or orbicular, 1½–3 cm. long, sometimes becoming glabrous above, tomentose below. *Flowers*: peduncles very short; calyx 3–4 mm. long, truncate, minutely 4-toothed or toothless; petals free, white, 10–15 mm. long. *Filaments* filiform, scarcely dilated towards the base; anthers red.

Apparently rare along South Australian coasts. The description copied from Black.

4. C. RUBRA Sm., Exot. Bot. II, p. 26, 1808. (Pl. 4, fig. 4.)

Shrub varying in height, with loose tomentum on the younger branches, becoming denuded when older. *Leaves* very variable, ovate or ovate-oblong, often subcordate at the base, sinuate, scabrous above, due to the surface being covered with minute warts, each of which when the leaf is young is surmounted by a bunch of hairs, the underside of leaves densely pubescent with soft white hairs mostly stellate in form. *Flowers* terminal, pendant or erect on short peduncles 3 mm. long, with two small ovate to lanceolate leafy bracts, which vary from under 10 to 15 mm. in length and in some bushes are absent. Calyx campanulate, with minute teeth or none, 3–5 mm. long, width 6–7 mm., colour 'Vinaceous Faun', densely tomentose with soft hairs: flowers have united petals, 'Nopal Red' fading to yellow in the four lobes which expand and measure 10 mm. long and 6·5 mm. wide, the tube with lobes measures 30·7 mm. long, 12 mm. wide, slightly campanulate. *Stamens* exserted beyond the lobes 4 mm., filaments glabrous, the four opposite the petals dilated at base, the other four subulate; anthers yellow.

Mt. Compass and Tiers Inman Valley, South Australia.

5. C. REFLEXA Labill., Nov. Holl. Pl. Specimen, II, p. 120, 1806. (Pl. 4, fig. 5.)

A rather tall shrub, branches densely tomentose with brown stellate hairs. *Leaves* ovate-orbicular to elliptical, appearing almost glabrous but really thickly covered with minute stellate hairs on the upper side, which is depressed or slightly concave above the veining ; the underside is minutely pubescent with white stellate hairs ; leaf-stalks 3 mm. long, densely tomentose with brownish stalked stellate hairs. *Flowers* terminal, axillary, drooping on very short peduncles. Calyx is 5–6 mm. long and broadly 4-toothed, densely pubescent with white stellate hairs ; the petals united, colour ‘ Dull Green-Yellow ’, tube and lobes 17·8 mm. ; lobes 8 mm. long, not expanding ; the flower broadly ribbed down centre of each lobe ; the surface covered with evenly distributed but spaced short white stellate hairs. *Stamens* exserted beyond lobes 7·6 mm. ; filaments glabrous, dilated at base.

Near Tunkalilla Beach.

6. C. CALYCINA J. M. Black, Fl. S. Austr. p. 692, 1929. (Pl. 4, fig. 6.)

Shrub about 3 ft., spreading, branches thickly sprinkled with soft short stellate hairs amongst which are scattered long branching hairs. *Leaves* oblong or ovate-oblong, rather thick, obtuse, 2–4 cm. long, depressed or slightly concave over veins, glabrous-rugose above, edge of leaves with scattered stellate hairs ; the underside covered with loose white stellate hairs; the leaf-stalk about 6 mm. long, thick and loosely covered with brown branching hairs. *Flowers* :—calyx-tube and lobes about 10 mm. long but the lobes three times the length of the calyx-tube itself ; the four lobes blunt and sprinkled with loose sub-stellate hairs and underneath a white pubescence ; the calyx, flower-tube and lobes together measure 30 mm., colour pale greenish-yellow, the lobes slightly expand and curve outwards, the tube longitudinally broadly ribbed down centre of each lobe, sparsely sprinkled with minute stellate hairs ; the tube not campanulate but long and narrow, about the same width for the full length. *Stamens* exserted 10 mm. beyond the lobes ; filaments glabrous and dilate at the base.

Valley of the Onkaparinga behind Hackham, is the first record for this species ; no pink flowers noticed as recorded from the Tiers of the Hindmarsh recorded by Black. I believe that the green-flowered *Correa* I found thirty years ago in the gorge of the River Sturt is this species, and am informed it occurs in the Torrens Gorge.

7. C. NEGLECTA E. Ashby. *C. glabra* Benth., Fl. Austr. I, p. 355 : J. M. Black, Fl. S. Austr. p. 340, and of other authors. Not of Lindley in Mitchell's Three expeditions into Eastern Australia, II, p. 48, 1839. (Pl. 4, fig. 7.)

A reference to Mitchell's book at once makes it clear that the species therein described as *C. glabra* is not the species under review, and as the book is not easily available I quote that description in full. Mitchell was at the time near the junction of the River Lachlan with the Murrumbidgee: he says, 'I found a new species of *Correa*, remarkable for its small, green, bell-shape flowers, and the almost total absence of hairiness from its leaves'.

The description published on the same page is as follows: '*C. glabra* (Lindl. MSS.); ramulis incanis, foliis ovalibus obtusis in petiolum angustatis glabris subtus punctatis; corolla brevi campanulata tomentosa 4-dentata calyce truncato cupulari triplo longiore'. *Note.*—It is astonishing that the brilliant scarlet-flowered species of *Correa* hereunder described, in which the calyx is without lobes or teeth, should have been associated by botanists with a small green-flowered species in which the calyx is distinctly toothed and its habitat is the far interior of New South Wales and under most dissimilar climatic conditions.

The species under review may be described thus: A dwarf rather spreading bush 60–150 cm.; the branches in the smaller examples virgate and thickly sprinkled with bunches of brown, almost black, minute spreading hairs, under 30 magnification it is seen that the hairs spread from dark-coloured warts and do not accurately accord with 'stellate hairs'. The leaves are 'Forest Green' (Ridgway), broadly ovate with rounded apex, thick, flat and smooth, thickened at the edge; although the surface is chiefly glabrous, there are scattered very minute white sessile stellate hairs, a few larger, and a few larger stellate hairs around the margin; the underside is paler in colour, due to pubescence composed of numerous very minute white stellate hairs, under thirty magnification amongst these are seen irregular rows of spaced stellate hairs of a much larger size; the petiole is up to 4 mm. long and in the younger branches clothed with the same tomentum as the branches; the larger leaves measure 17 by 12 mm. and the smaller 12 by 5·5 mm. *Flowers* axillary, pendulous–subpendulous; peduncle short (5 mm.), bearing at its base a pair of smooth thick spathulate bracts of the same length as the peduncle; calyx 5·6 mm. long and 7·1 mm. wide, cup-shaped, persistent, truncate, varying in colour between 'Bice-Green' and 'Apple-Green' (Ridgway), without teeth or lobes, glabrous but for widely spaced sessile stellate hairs; in some cases small black warts occur which may be due to damage by sucking insects; flower scarlet, spreading; petals 4, valvate, much longer than calyx-tube, slightly campanulate; flower-tube 6·5 mm. in diameter at its junction with the calyx, increasing to a diameter of 9·6 mm., length of tube and lobes 21 mm., the tube and lobes appear minutely rugose, but under a higher power hairs the same colour as the tube appear. *Stamens* 8, which appear exserted owing to the reflex lobes, but really they are of the same length as the tube and the lobes together; filaments slender, glabrous, dilated at the base, the four opposite to the petals dilate to double the width of any of the other species dealt with in this paper; the anthers without terminal appendages. *Carpels* 4, 2-ovulate; style long, slender, with small bilobed stigma; disk shallow, 8-lobed; fruitlets normally 4, 1–2-seeded.

Cape Spencer, York Peninsula. It seems a coastal species, its exact range undetermined.

7 *a.* C. NEGLECTA var. MINOR E. Ashby. *C. glabra* J. M. Black in part, but not of Lindley ex Mitchell; Ewart, but not of Andrews. *C. speciosa* of nurserymen. Possibly listed by Bentham under his hybrids of *C. speciosa* =*C. rubra.* (Pl. **4**, fig. 7 *a.*)

I believe this form is subject to a good deal of variation. If it be found to be a geographic race it could then be raised to subspecific rank.

It differs from *C. neglectus* (sensu stricto) in that the leaves are almost lanceolate with blunt apices, much upcurved or concave on the upper side, whereas in *C. neglecta* the leaves are broadly ovate in the larger ones, flat and thick; in this var. the larger leaves measure 19 by 7 mm. and are less thick. *Flower* not campanulate but the sides straight and taper from the lobes to the calyx; at the base of the floral lobes the diameter 8·5 mm. and at the calyx 5·4 mm., the colour is 'Peach Red' (Ridgway) instead of 'Scarlet'.

Correa neglecta, sp. nov. *Frutex* pumilus, 60–150 cm. altus; surculus pubescens sparse stellatim-pilosus. *Folia* decussata, elliptico-ovata, crassa, plana, glabra, 12–17 mm. longa, c. 5·5–12 mm. lata. Flores axillares, penduli vel subpenduli; pedunculus 5 mm. longus, bracteis duabus spathulatis; floris tubus basi campanulatus, tubus plus lobi 21 mm. longi, non plus 9·6 mm. lati, lobi expandentes. *Calyx* cyathiformis, persistens, truncatus, sine dentibus vel lobis, glaber, 5·6 mm. ongus, c. 7 mm. latus. *Petala* 4, valvata, multo calycis tubo longiora, coccinea. *Stamina* 8, 21 mm. longa. *Fructus* (carpelli) 4; discus brevis, 8 lobis; stylus longus, gracilis; stigma bilobatum.

8. C. TURNBULLII E. Ashby. (Pl. **4**, fig. 8.)

Shrub of about 2 ft., compact and erect in habit (the adult bush has not been seen); branches tomentose with widely spaced stiff stellate hairs. *Leaf*-stalk about 3 mm. long, eaves decussate, ovate-oblong, obtuse, 2–3 cm. long by varying width, glabrous-rugose above, densely pubescent beneath with white stellate hairs, margin of leaves revolute. *Flowers* axillary, more or less erect; peduncle short, 2–3 mm. ong with a pair of leafy bracts at the base, the stalk of the bracts nearly as long as the peduncle, the bract including ts stalk is 5 mm. long and elliptical; calyx cup-shape, persistent, without lobes or teeth, about 5 mm. long with paced pubescence, in the upper half, more crowded in the lower half with stellate hairs, larger stellate hairs with short thick stalks along the margin which is sinuate ; petals 4, valvate, much longer than calyx-tube, tube with lobes 17 mm. long and 7 mm. wide, lobes themselves 6·5 mm. long ; the flower-tube only slightly expanded, when first open is ‘ Spinel Red ’ fading to ‘ Amaranth Purple ’, lobes ‘ Light Green-Yellow ’ dulling somewhat with age, the flower tube is evenly sprinkled with spaced stellate hairs, the same colour as the tube. *Stamens* exserted about 9 mm. ; filaments slender, glabrous, the same colour as the flower-tube ; anthers without terminal appendages. *Carpels* 4, 2-ovulate ; style long and slender, with small bilobed stigma ; disk shallow, 8-lobed ; fruitlets normally 4, 1–2-seeded.

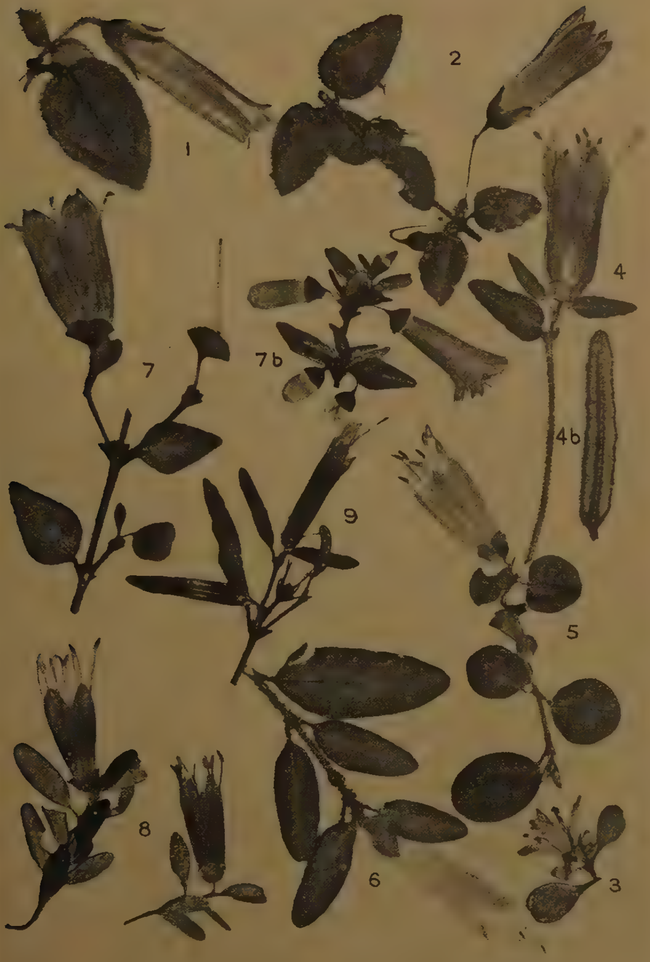
Chaunce's Line (Hd. Freeling), near the Fauna and Flora Reserve. No mature bush was seen, described from example grown at ‘ Wittunga ’ from seedlings dug up from a depression.

I have much pleasure in naming this *Correa* after my friend Mr. J. J. Turnbull, who has rendered much help in the collecting of native shrubs and in work connected with the obtaining of the Fauna and Flora Reserve adjoining which this *Correa* was discovered.

Correa Turnbullii, sp. nov. *Frutex* pumilus, 60 cm. (frutex adultus non repertus) ; surculus tomentosus sparsim stellatim-pilosus. *Folia* decussata, ovata-oblonga, inferne albis stellatis pilis ; margo folii revoluta. *Flores* axillares, plus minusve erecti ; pedunculus brevis, 2–3 mm. longus, bracteis duabus foliosis 5 mm. longis ; color florum aperientium ‘ Spinel Red ’ pallescens ad ‘ Amaranth Purple ’ (Ridgway Color Standards) ; lobi ‘ Light Green-Yellow ’. *Calyx* cyathiformis, persistens, truncatus, sine dentibus vel lobis, c. 5 mm. longus, pubescens pilis sparsis in superiore dimidio, subter pilis densioribus. *Petala* 4, valvata, calycis tubo multo longiora, tubi lobis 17 mm. longis 7 mm. latis ; lobi modo subexpandentes. *Stamina* 8, exserta c. 9 mm., filamenta gracilia, glabra, colorata ut floris tubus. *Fructus* (carpelli) 4, 2-ovulati ; discus breviter lobatus ; stylus longus, gracilis ; stigma bilobatum.

9. C. DECUMBENS F. Muell. in Trans. Vict. Instit. I, p. 30, 1855, and Pl. Vict. I, p. 137. (Pl. **4**, fig. 9.)

A prostrate shrub with long virgate branches, a little more erect where not eaten by stock ; branches with brown tomentum and scattered long stalked stellate hairs. *Leaves* long and narrow, 1½–3½ cm. long, revolute margins, obtuse, glabrous and slightly rugose above, soft tomentum below. *Flowers* solitary on short peduncles ; calyx with four long subulate teeth alternating with four short deltoid teeth ; flower-tube ‘ Indian Lake ’, lobes ‘ Absinthe Green ’, style ‘ Lime Green ’ ; petals united, about 25 mm. long, densely pubescent with hair of the same colour as the tube ; lobes greenish, about 5 mm. long. *Stamens* exserted (about 8–10 mm. beyond lobes) ; filaments with scattered loose hairs,



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CORREA SPP. FROM SOUTH AUSTRALIA.

(in this respect this species differs from the other eight species dealt with in this paper).

Comparisons of the three new species described.

C. affinis differs from *C. aemula* in having entirely different tomentum ; in having thin leaves instead of thick ; in slender peduncle, which is very thick in *C. aemula* ; in having bracts at the base instead of near middle of peduncle ; in bracts being very small, orbicular instead of large and leafy ; in possessing bracteoles which are absent in *C. aemula* ; in calyx being almost glabrous and half size of *C. aemula*, which is covered with loose tomentum.

C. neglecta differs from *C. rubra* in the character of the tomentum ; in the form and surface of the leaves ; in the form and surface of bracts ; in that the soft pubescence of calyx of *C. rubra* is entirely absent in *C. neglecta.*

C. Turnbullii differs from its nearest relative *C. decumbens* in that *C. Turnbullii* is an erect and compact bush while *C. decumbens* is prostrate and spreading ; the leaves of *C. Turnbullii* are short and broad, in *C. decumbens* long and narrow ; in calyx of *C. Turnbullii* there are no lobes or teeth, in *C. decumbens* there are both ; *C. Turnbullii* has leafy bracts, *C. decumbens* none.

Correa Turnbullii differs even more widely from all the other species dealt with in this paper.

EXPLANATION OF PLATE 4.

Fig. 1. *C. aemula,* showing flower, pair of bracts, and one leaf.
Fig. 2. *C. affinis,* showing flower, pair of small orbicular bracts at base of peduncle and minute bracteole.
Fig. 3. *C. alba,* showing flower with petals free and leaf.
Fig. 4. *C. rubra,* showing flower and leaves.
Fig. 4 *b*. *C. rubra* var. *grandiflora* Audas, leaf only from Grampians.
Fig. 5. *C. reflexa,* showing flower and leaves.
Fig. 6. *C. calycina,* showing flower and leaves.
Fig. 7. *C. neglecta,* showing flower, leaves and pair of spathulate bracts.
Fig. 7 *b*. *C. neglecta* var. *minor,* showing flower and leaves.
Fig. 8. *C. Turnbullii,* showing two flowers and leaves and pair of leafy bracts at base of peduncle.
Fig. 9. *C. decumbens,* showing flower and leaves.

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